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Recreation on Water Supply Reservoirs

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Recreation on Water Supply Reservoirs

A Handbook for Increased Use

Sponsored by the Council on Environmental Quality

Wash. D.C. → September 1975

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Preface

This handbook is designed to help citizens, especially those living in the Northeastern United States. In most parts of the country, water supply reservoirs and surrounding land areas provide a wide range of recreation opportunities, including hiking, boating, fishing, and even swimming. But in other places public access to reservoirs and lands surrounding them has traditionally been severely restricted or altogether prohibited. This is particularly true in six states — Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island — where 47 million people live. It is the message of this handbook that with proper planning, management, and water treatment facilities, water supply reservoirs in these states and in other restricted areas throughout the country could provide both safe drinking water and greatly expanded outdoor recreation facilities.

Historically, reservoirs in the Northeast have had restricted public access to protect public health. While such a policy in the past may have been essential and workable, today it is neither. It is not essential because improvements in water treatment technology which are widely used, and which are likely to be required in the near future on all surface reservoirs, make possible the safe use of reservoirs and lands for a range of recreation activities. It is not workable because restrictions on access alone can no longer be relied upon as a substitute for water treatment. Encroaching urban areas, increasing security costs, and emerging information about the quality of drinking water supplies make more extensive water treatment virtually inevitable. Under such circumstances, recreation becomes not only a compatible use; it is also a very practical way to insure the public support necessary for continued long-term protection of the watershed from the encroachment of other more intensive uses.

This handbook was prepared through a contract with Urban Systems Research and Engineering, Inc., of Cambridge, Massachusetts. Technical material concerning water supply, recreation, and risk to public health was reviewed by three of the nation's foremost experts on water supply:

Dr. J.C. Morris, Gordon McKay Professor of Sanitary Chemistry Harvard University.

Dr. E.R. Baumann, Anson Marston Distinguished Professor of Engineering, Iowa State University.

Dr. E.F. Gloyna, Dean, College of Engineering and Joe J. King Professor of Engineering, University of Texas.

Their comments and assistance were particularly helpful. In addition, Mr. James McDermott, Director of the Water Supply Division of the Environmental Protection Agency, provided valuable assistance.

We believe this handbook constitutes a valuable guide to many issues of drinking water quality and treatment which have taken on new importance with the enactment of the Safe Drinking Water Act of 1974. In particular, we hope it will be helpful to citizens in the Northeast who wish to expand the beneficial uses of reservoirs by opening them up to outdoor recreation.

Russell W. Peterson

Chairman
Council on Environmental Quality

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The Issue in Brief

As our urban population grows and development spreads into the countryside, opportunities for outdoor recreation have become both more difficult to find and more urgently needed. Recreation facilities close to population centers are often crowded, and access to more distant natural sites is difficult. People are less able to enjoy the pleasures of natural areas and find the relief from urban pressures which contact with the natural world can provide.

Close to many cities lie beautiful water supply reservoirs, protected over the years by careful watershed management. In most regions of our nation, recreation of all forms is permitted on these reservoirs. Yet in the Northeastern states, where millions of Americans are concentrated, public access to reservoirs and the surrounding lands is generally restricted or prohibited altogether. This handbook is designed to inform citizens of the Northeast of their opportunity to make use of these reservoirs for outdoor recreation.

In the nineteenth century, the Northeastern states pioneered water treatment and supply technology in this country. Standard practice called for rigid restrictions on public access to watershed lands and the water itself. This practice was very successful in protecting public health. No conflict with public recreational needs existed because cities were smaller and nearby rivers, lakes, and streams were less polluted.

Today the situation has changed. Development has spread into many watersheds in the Northeast. New and exotic substances are finding their way into our water supplies. Water which was recently pure is now known to contain viruses, pesticides, fertilizers, salts, heavy metals, and other substances potentially damaging to health.

Fortunately, drinking water technology is now capable of treating and purifying water at relatively low cost. Standard water supply practice recognizes the need for more extensive treatment of all surface supplies. These improvements in water treatment technology make most forms of recreation — including water contact activities such as swimming — completely compatible with the production of safe, high quality drinking water. Hence unfulfilled demands for recreation near major urban areas could be met through greater use of these beautiful reservoirs.

Although modern water treatment can eliminate risks to public health from expanded recreation, old traditions stand in the way of increased recreational use of water supply reservoirs. Four of the states considered in this handbook — Massachusetts, Connecticut, Rhode Island and New York — have laws and regulations which prohibit any form of body contact recreation in water supply reservoirs. The other two — New Jersey and Pennsylvania — limit the activities available.

The managers of water supply systems have little reason to expand recreational opportunities at the reservoirs they operate. Water managers are usually isolated from agencies responsible for public recreation. They are often concerned that the cost of increased recreation would be paid out of their budget with no assurance of increased revenues to maintain production of safe drinking water. They anticipate added managerial problems and even criminal liability for accidents. From their point of view, recreation is of no benefit to their primary responsibility and, therefore, they resist change.

Whether to allow recreation on water supply reservoirs and the adjacent land is an old controversy in professional circles. This handbook is not another study of that subject. Rather, it is an educational tool, written in non-technical language, for citizens interested in the recreational uses of water supply reservoirs and the broader issues of water supply as well.

This handbook suggests the need for new policies under which advanced treatment of drinking water becomes standard and recreation on and near reservoirs is encouraged. Properly managed recreation is now one of the most important uses of watershed lands, a use which maximizes public benefits from land which must be specially protected. But such change in the established policies is a political choice. This handbook is designed to assist the public in making that choice.

The choice must be based on knowledge of local conditions. While this handbook presents information and guidelines for planning increased recreation, each reservoir is likely to be unique in some respects. Therefore the appropriate solution for individual reservoirs must be analyzed with care.

This handbook is divided into three chapters. The first chapter describes the issue in its past and present context. It outlines the history of water supply in the United States with emphasis on the progress of water treatment and describes the present situation in the Northeastern states through case studies. It concludes with a summary of the major concerns which have dominated the controversy.

The remaining chapters present reference material for planning increased recreation. Chapter Two summarizes the relevant laws and regulations of the six most populous states in the Northeast — Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. These densely populated states have extensive reservoir systems which could provide valuable recreational opportunities.

Chapter Three provides information useful for planning recreation at reservoirs. Different forms of recreation are examined in terms of their suitability and their compatibility. Guidelines are suggested to help determine which activities are appropriate at a specific site. Costs and cost recovery mechanisms are presented, and institutional constraints on recreation are examined.

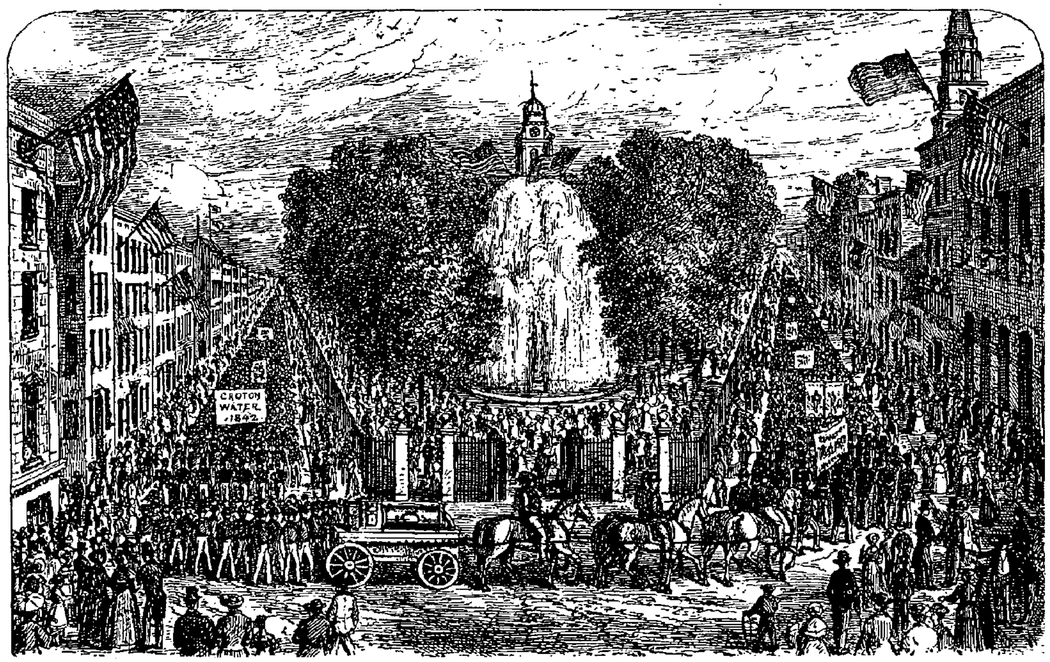
Appendix I provides a technical description of the capabilities of water treatment technologies to remove contaminants commonly associated with recreation. The recent controversy concerning drinking water quality and chlorination is discussed in that chapter as well.

Appendix II contains supplementary reference material on reservoir recreation in each of the six states discussed in Chapter Two, including transcripts of the relevant portions of state laws.

A Glossary of terms and an annotated bibliography complete the handbook.

1
Reservoir Recreation in Perspective

The Croton Water Celebration, 1842



The issue of recreation on water supply reservoirs is part of the history of water supply. By the first quarter of this century, most of the water-borne pestilences which caused so much suffering had been virtually wiped out by the broad advance of public health science. The progress of water supply technology was a principal element of this success.

This section of the handbook outlines the history of water supply in the United States. The emphasis is on systems in the Northeast, but reference is made to conditions elsewhere in this country and in several European countries. The case for increased recreation on water supply reservoirs is presented in the light of new circumstances which are challenging traditional attitudes toward water supply management.

This case relies heavily on the assumption that recreation will not conflict with the protection of public health. The production of safe drinking water has priority over all other objectives of water supply management. But with adequate treatment, all forms of recreation are compatible with the protection of public health. The technical justification for this statement is contained in Appendix I, but modern water treatment techniques are outlined below. Examples of successful recreational uses of water supply reservoirs are presented, and the chapter concludes with a summary of the case for increased recreational use of water supply reservoirs.

History of the First United States Water Systems

> "There is no truer sign of civilization and culture than good sanitation. It goes with refined senses and orderly habits. A good drain implies as much as a beautiful statue."[1]

Public water supplies were set up to counter very real and severe threats. Throughout history, disease has claimed far more dead than have wars. In fact, wars have sometimes been ended by outbreaks of water-borne disease, such as when Louis IX, leading the last of the crusades in Tunis in 1297, was killed by dysentery along with his son and most of his army. In our own history, Abigail Adams, wife of John Adams, our second President, died of water-borne typhoid in 1818, and Zachary Taylor, the twelfth President, died of it in 1850. Since the scientific basis of disease transmission was poorly understood until comparatively recently, only common sense guided people's behavior in the water they used. Common sense proved insufficient to guard against the invisible organisms of disease.

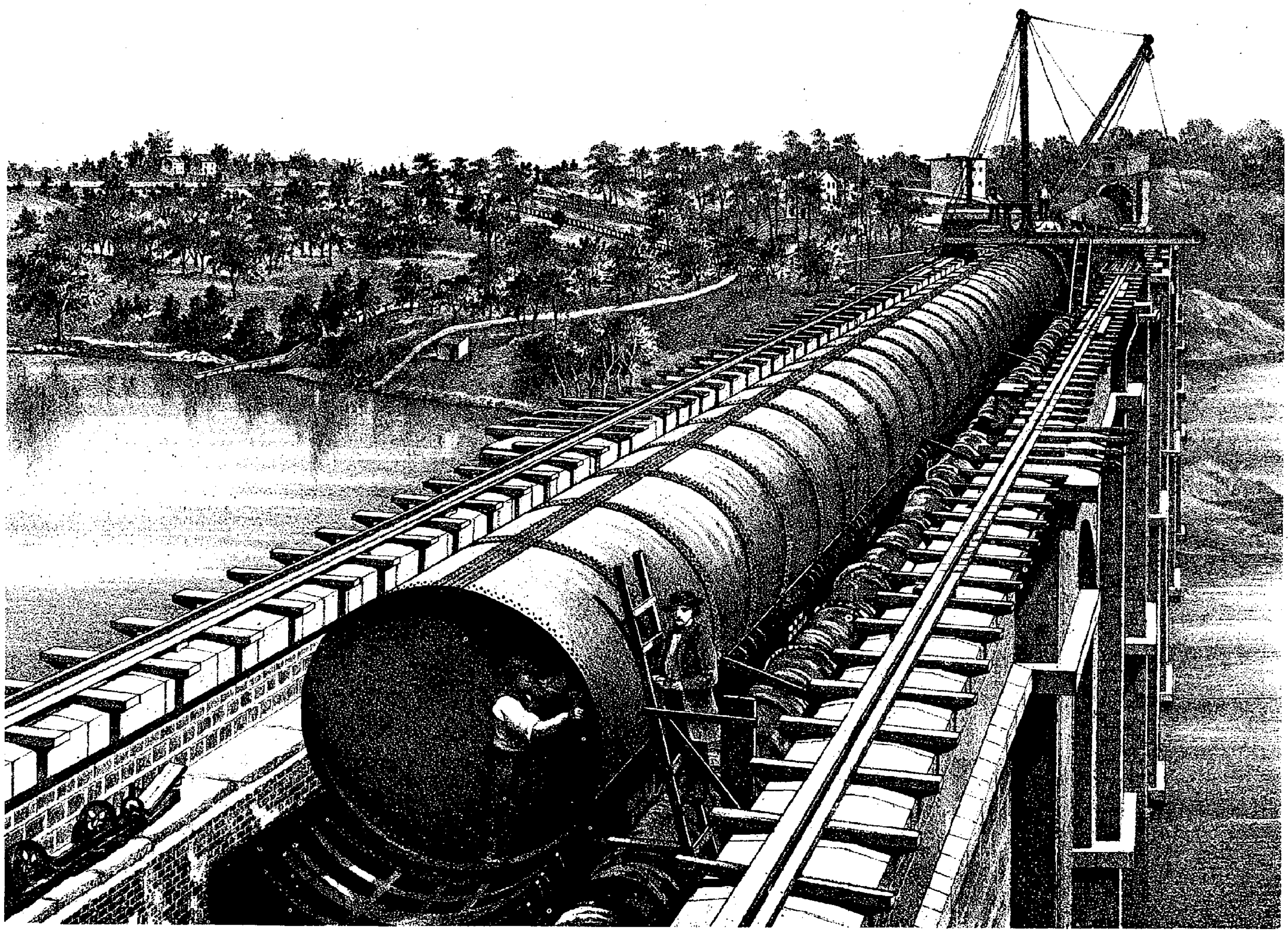
Often people were forced to accept obviously inferior water. In many instances, there was no choice in the matter. In the old cities, the only available water came from polluted shallow wells. These wells were often near privies and graveyards, and household wastes accumulated in the streets and drained noxious substances into the groundwater.

Not only was the water unhealthy, but there was comparatively little of it. As cities grew in the nineteenth century the wells and local streams became insufficient for the populations which grew up around industry.

Philadelphia was the first American city to come to grips with the water supply problem. In 1739, a yellow fever epidemic terrorized the city. In the course of three months, four thousand people, or ten percent of the city's population, died. Business came to a standstill in the nation's largest port since more than half of the citizens had fled to the surrounding countryside. Most of those who stayed behind avoided all contact with the sick. Travelers from Philadelphia were quarantined from other cities, and relief supplies and financial aid were sent to help the striken national capital. Later in the decade, the epidemic struck New York, New Haven, Baltimore and other cities, and revisited Philadelphia with vengence in 1798.

Yellow fever is not transmitted by water but by the *Stegomyia Fasciata* mosquito. But even then it was recognized that the filthy conditions of the city contributed to the breeding of mosquitos and to the general public vulnerability to disease. Large amounts of new water would be required to clean up the city. To obtain it the Philadelphia Water Works was developed. The Schuylkill River was dammed and water pumped into a small number of households by means of steam engines. Water was available free from public hydrants on the streets, a policy which contributed to the eventual financial failure of the enterprise. The soft surface water was

Aqueduct High Bridge During Construction, Croton, New York, 1862



excellent for washing and cooking, but the population preferred the taste of the cool, mineral laden well water. Nonetheless, Philadelphia's Water System was the envy of many cities, notably Boston and New York, which had suffered several water shortages.

It must be remembered that one crucial use of public water was the fighting of fires. The establishment of the earliest water companies, which delivered water by truck around the cities, was often catalyzed by the outbreak of devastating fires. A pure supply of water was needed for personal consumption, and a plentiful supply was mandatory for fighting fires. The wells were insufficient on both counts. It remained to be seen which catastrophe — fire or pestilence — would move cities to provide new water supply. For New York, unhappily, it was both.

In the early 19th century, New York's only supply of water was from wells owned by the Manhattan Company. After only a few years of operation, those wells were impure and manifestly inadequate for the service of such a large city.

In 1831, the New York Lyceum of Natural History presented a report to the City Council which alleged widespread contamination of the city's wells by privies and graveyards. The report made the disquieting observation that only the absorption of large amounts of urine into the well water prevented it from being worse, as the chemical reaction tended to precipitate out some of the impurities.

One complaint concerning the water was registered by the brewers of the City of New York. They petitioned for a clean water supply in order that the quality of their beer be improved. New York breweries were rapidly losing their business to those in Philadelphia, which had clean water supply and better beer.

A new disease struck: Asiatic Cholera. Reports of its existence were received in dispatches from Egypt, then Austria and Germany, and finally the British Isles. In June of 1832, cholera crossed the Atlantic and was reported in Canada, and soon moved toward New York. Attempts were made by a frightened state legislature to quarantine Albany, but to no avail; cholera struck Albany and headed south.

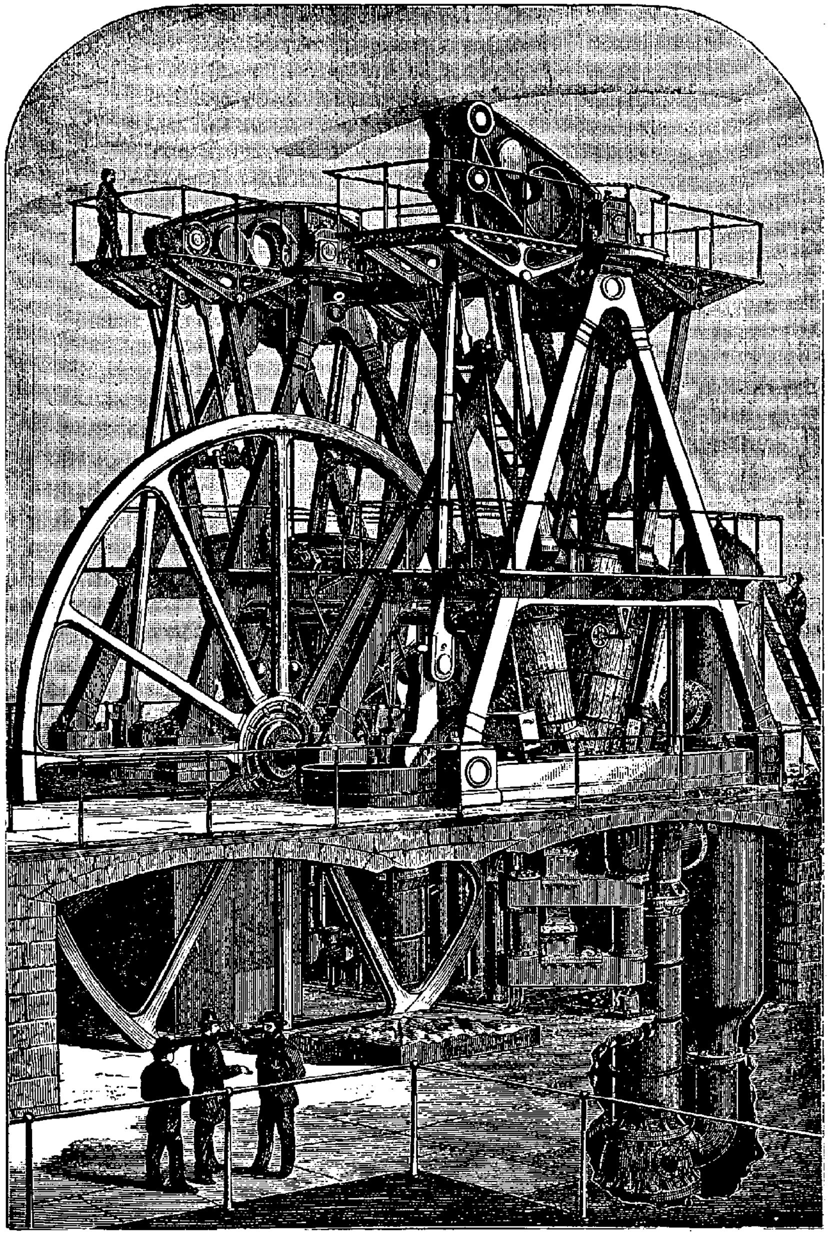
Thinking that bad air was responsible for the disease, New York did its best to clean up its streets to ward off the epidemic. Nevertheless cholera entered the city in July and did not run its course until October. Thirty-five hundred people died, and at least 100,000 people fled the city, causing great losses to business and industry. Worst hit among the population were the poor, and moralists were quick to blame their disaster on bad habits and intemperance.

The truth was otherwise, of course, Cholera can be water-borne and was able to thrive in the poorest areas of the city due to lack of sanitation and the contamination of local well water. Philadelphia escaped the epidemic with relatively few casualties — only about 900 lives were lost. The city's good water supply and adequate sewerage saved it much suffering, and the toll would have been lower had not so many old wells and privies remained in service.

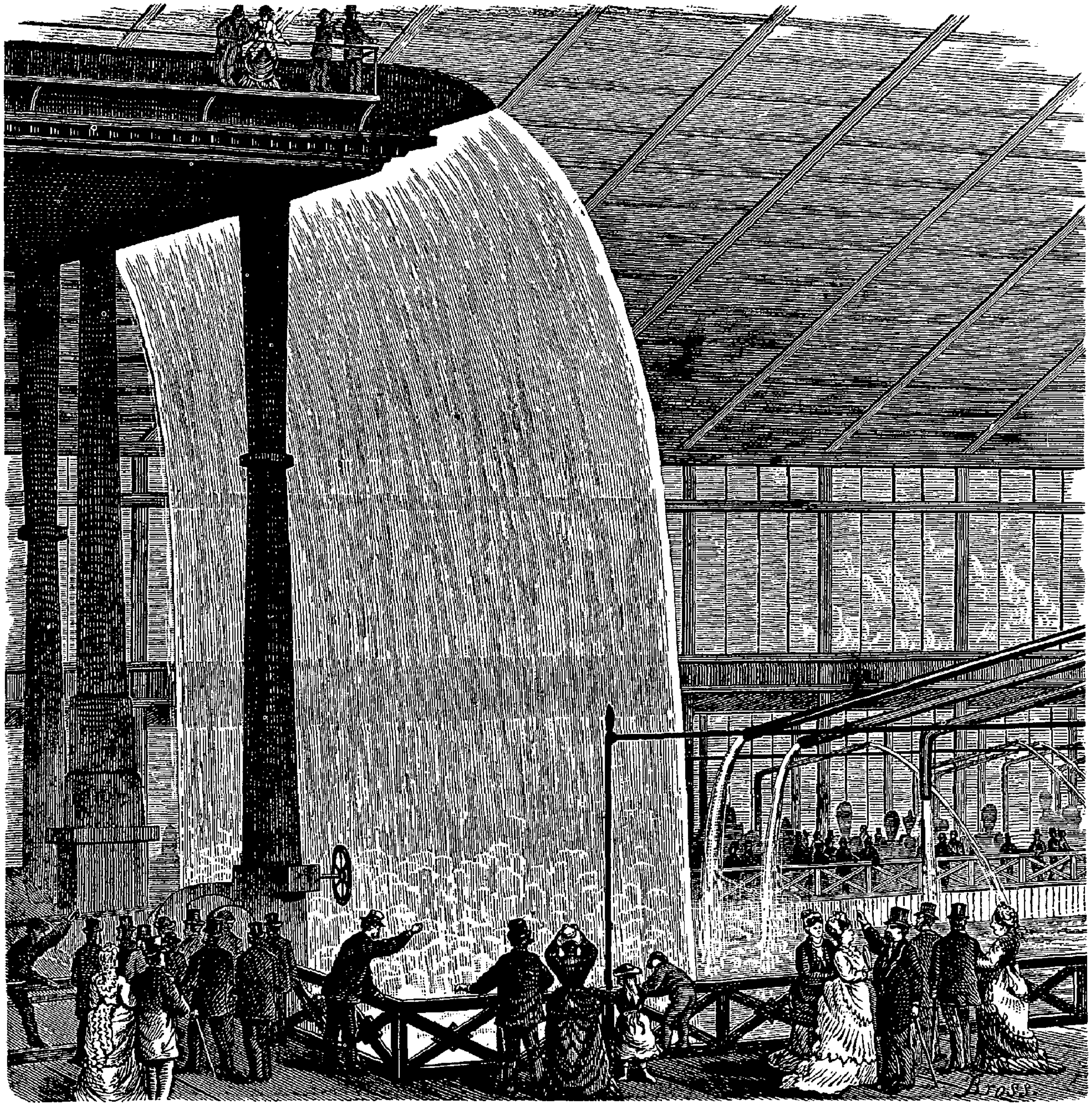
The lesson was not wasted on New York, but adequate water was not available in time to avert another tragedy. By 1835, the massive Croton aqueduct project was approved and construction begun; in December of that year New York suffered the worst fire in its history. A former mayor described it as "the greatest loss by fire that has ever been known, with the exception perhaps of the conflagration of Moscow."[2] Twenty blocks of valuable buildings were destroyed, 2000 merchants were ruined, and almost all of the city's insurance companies were bankrupted.

Boston was more fortunate than New York and Philadelphia. It did not suffer the same cataclysms as New York, and benefitted by the experience of both cities in the design of its own system.

This background explains why, when the water systems finally were finished and the first water flowed toward the Cities of New York and Boston, the public celebration was nothing short of ecstatic. In New York, on October 14, 1842, a water festival was held which celebrated the new water works with great extravagance; the day began with firing of cannons and ringing of churchbells, a five-mile long parade, and speeches by an entourage of political dignitaries. Fountains had been built throughout the city, and when the parade finished passing City Hall at five in the afternoon, parties and private celebrations



Leavitt Laurence Pumping Engine,
A Late 19th Century Water
Distribution Pump



began in every borough.

Six years later, Boston rivalled New York in its civic festival celebrating the opening of Cochituate Reservoir, known formerly as Long Pond. According to the water commissioners, Cochituate was an Indian name which meant "an ample supply of pure and soft water, of a sufficient elevation to carry into the City of Boston, at a moderate expense." The entire faculty and student body of Harvard University marched in a parade which also included Father Matthew's Mutual Benevolent Total Abstinence Society, the Sons of Temperance, the Citizen's Water Committee, and various scientific, historic and musical societies. When the parade was over, 100,000 spectators watched Water Commissioner Nathan Hale open the valve on an eighty foot tall fountain. As the sun set, Mayor Quincy announced that the fountain would run all the next day and that school children would have the day off. The day ended with fireworks and parties throughout the city.

Hydraulic Annexe at the Centennial Exposition, Chicago, 1876

Establishing Water Treatment

Regarding "animalcules:"

"It is. . . quite useless to expect to obtain water from a source which will be free from these repulsive living beings. The only remedy against them is, to avoid too curious a search by microscopic eyes. . ."
Nathan Hale, Boston Water Commissioner[3]

While Hale did go on to recommend that something be done when "animalcules" get big enough to be seen by the naked eye, his ostrich-like position did little to convince citizens. Though some went so far as to reason that animalcules showed the water was pure, since they could not live in poisoned water, wiser heads ultimately prevailed.

Since most city water had traditionally been drawn from wells, tests for water purity were aimed at determining hardness, which is a common problem with groundwater supplies. Hardness can give water a brackish taste, and make washing and cooking difficult. Since the germ theory of disease was not yet discovered, microorganisms in well water remained unknown and unidentified.

Lake water, however, contained large insects and other "animalcules" visible to the naked eye. Smaller organisms could be seen under microscopes. People found the animalcules repulsive, hence Hale's attempt to prove they are of no consequence. Various measures were suggested to prevent the growth of animalcules in water.

When the water began to be drawn

from surface sources, the responsible city officials often took steps to isolate the supply. In 1803, the Philadelphia City Council passed an ordinance that "every person who should throw into the basin or canal any kind of filth, or should go into the water to wash or bathe, or should cause any dog or animal to go into the water, should be fined $5 plus costs." In 1832, a stricter law was passed with a fine of $5 to $50. When New York built the Croton Reservoir, the City Council assessed a fine of $50 on anyone who bathed or threw stones or dirt into Croton or the aqueduct. While these laws were logical as a practical measure, there was no understanding of the biological relationships involved.

Little regard for treating the water was evident until late in the century. Municipalities tended to believe that a lake or a stream had the ability to purify itself if left undisturbed. While this is true to a certain extent — running water tends to oxygenate itself and satisfy biochemical oxygen demand (BOD) and standing water will clarify itself by sedimentation — the effects do not sufficiently protect a populace from disease organisms. As is now being discovered in the field of viruses, a relatively small number of pathogenic organisms can have a significant health effect. Even if natural processes destroy 90% of the pathogens, the remaining 10% can infect large numbers of people. Modern water quality managers feel no organisms should remain in water delivered to the public.

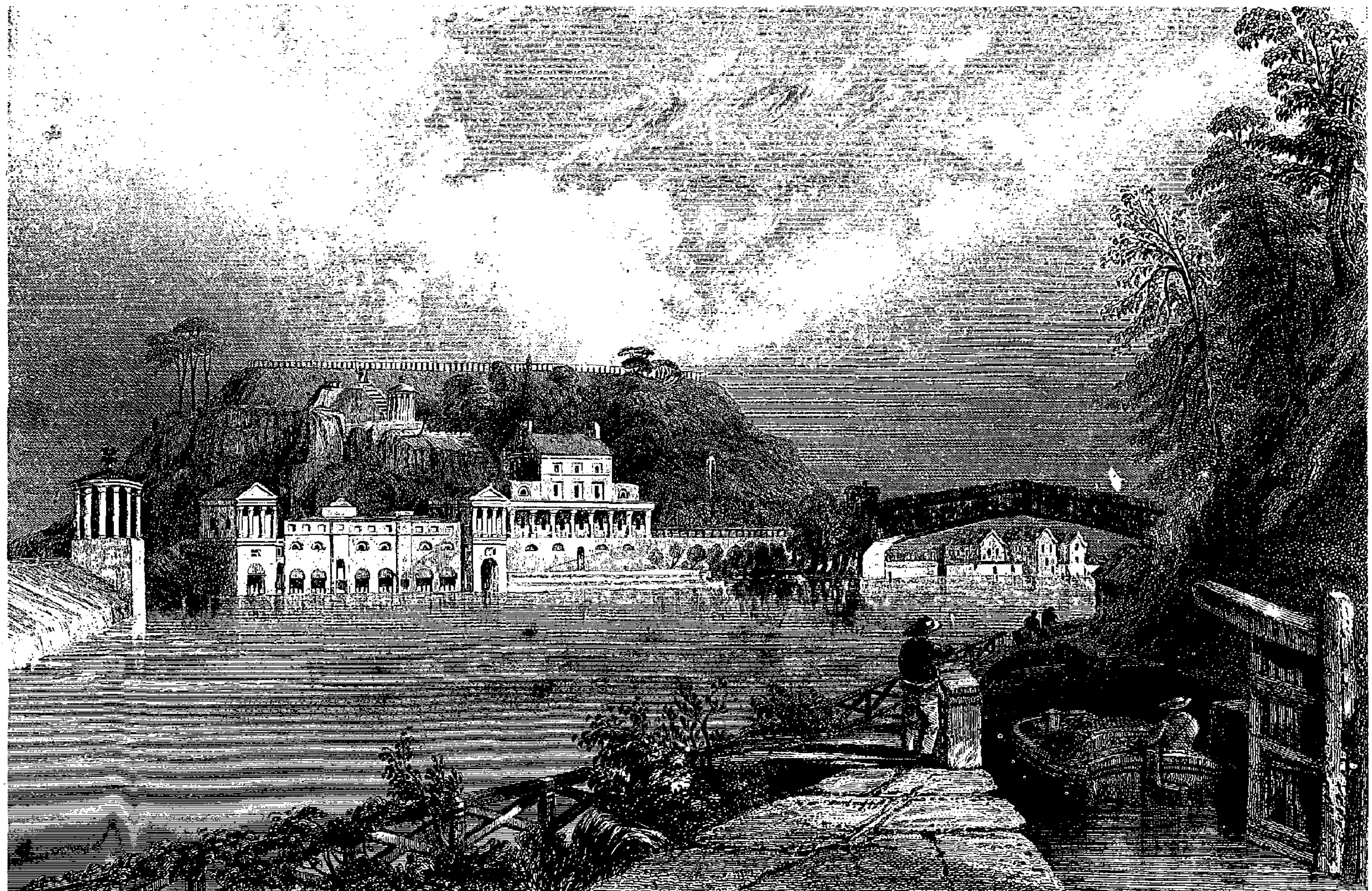
In 1812, John Melish suggested that Philadelphia filter its water supply with a device developed in Paisley, Scotland. Residents of Philadelphia already used similar devices called "filter jars" in their homes to clarify the water for consumption. In 1831, Fyler Dibblee of New York noted,

> "The citizens of Philadelphia are a contented people; they have the Schuylkill by their side; and, from necessity, they improve it to the best advantage; but that water is not fit to drink without undergoing the process of filtration. I am informed, from indisputable authority, that insects may sometimes be seen in it one-fourth of an inch in length."[4]

The process of filtration suggested by Melish was the so-called slow filter. In this process, water is allowed to seep through a bed of sand. After a time, a jelly forms around the sand particles of the upper layers of the bed. After an adequate amount of this jelly has accumulated, it acts biologically to kill organisms and oxidize organic matter. Later in the 19th century, the rapid filter was perfected. For this type of treatment, a coagulating substance such as alum is added to the water to produce a precipitate or floc which entraps impurities and is then easily removed by filtering. A rapid filter permits more water to be processed per acre of filter bed, and achieves effective treatment at comparatively lower cost.

Filtration was popular in Europe, which had more severe water supply problems than the United States. Europe's cities, being older, had to

Schuylkill Water Works, Philadelphia, 1844



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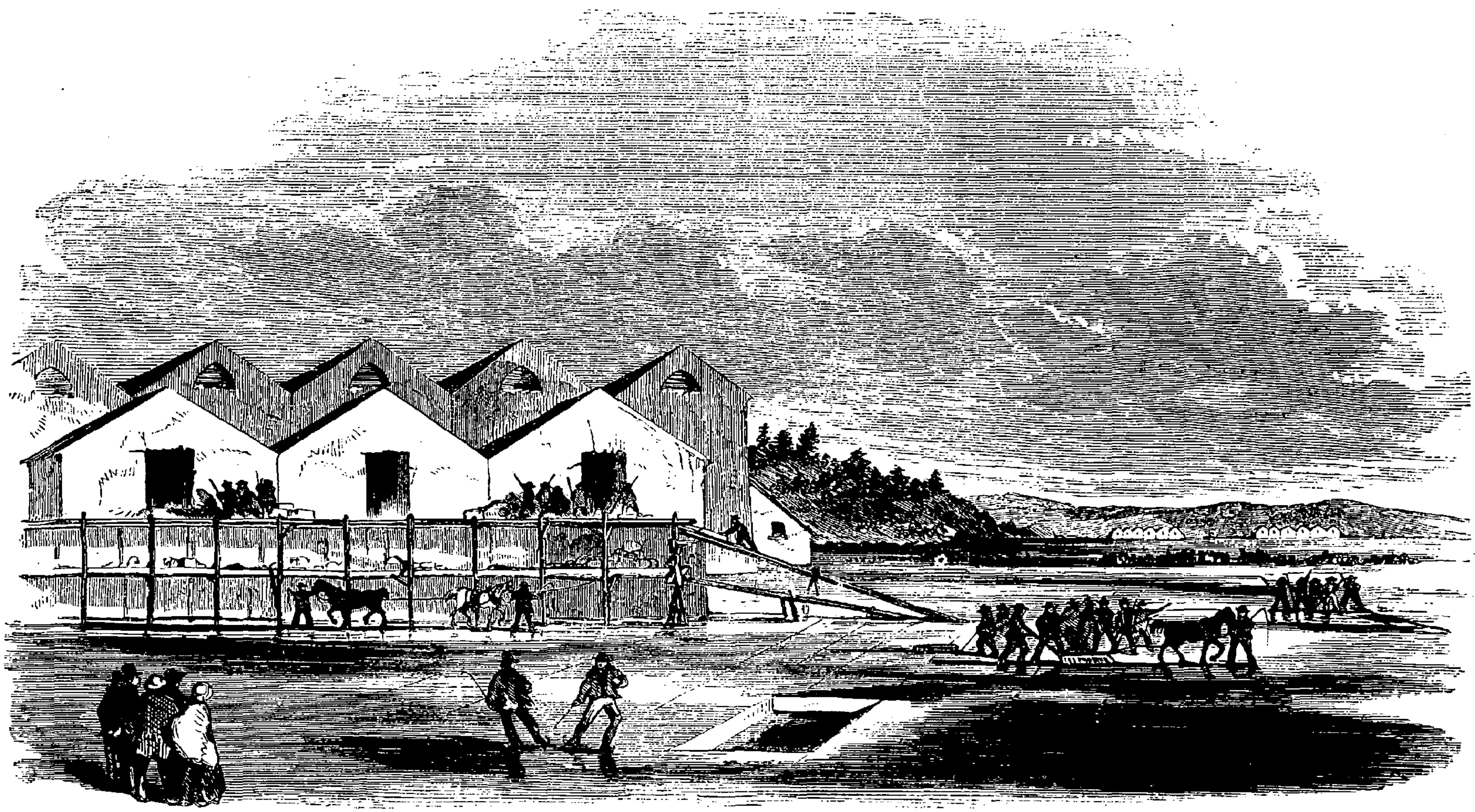


Ice-cutting at Fresh Pond, Cambridge, Mass. 1855

cope with higher population densities and more dilapidated sanitary facilities. Cholera was widely feared during the half century when filtration was proving itself effective in removing disease pathogens from drinking water.

In 1854, an epidemic in London conclusively established the relationship between contaminated well water and disease. In the parish of St. James, which had a population of 36,000, an epidemic of cholera killed 700 people in 17 weeks. Water in the parish was drawn from wells lined with porous lime-mortared brick. A thorough investigation of the outbreak by Dr. John Snow revealed that almost all the cholera victims had drunk water from the well on Broad Street. Further research discovered that a case of cholera had occurred some weeks before at a house near the well. Seepage from the dilapidated cesspool of that residence had penetrated the well's porous brick lining. This discovery was a milestone in the advancement of public health research.

Between 1836 and 1876, eleven U.S. cities considered filtration of their water but did not adopt it. In 1836, for example, Robert Eddy advised Boston against filtration, recommending instead that the city go as far afield as necessary to obtain water which would not need filtration. Boston still follows this policy today.

A turning point in the history of filtration in the United States came in 1859 when James Kirkwood went to Europe to study filtration on behalf of the City of St. Louis. His findings were published in a report entitled, *Filtration of River Water for the Supply of Cities as Practiced in Europe.* St. Louis declined to build a plant, but Kirkwood's investigations found an audience elsewhere. In 1872, the first successful slow sand filter was built in Poughkeepsie, New York, to process water from the Hudson River. The next successful plant was installed in Lawrence, Massachusetts in 1893.

In this same year, an outbreak of cholera occurred in Germany which provided a dramatic lesson in the value of filtration and hastened its adoption in the United States. Two cities on the Elbe, Hamburg and Altona, were involved. While adjacent, they had separate governments and separate water systems. Hamburg drew water from the river seven miles above its sewage outfall; Altona drew its water seven miles below the Hamburg outfall. Altona was thus vulnerable to the contamination from all 570,000 residents of Hamburg. In 1892, a cholera epidemic spread in Hamburg causing 16,956 cases and 8,605 deaths. Amazingly, Altona developed only 500 cases, most of which were contracted in Hamburg, and only 300 people died. The explanation of the disparity was that Altona had a slow sand filtration plant in its system, and Hamburg had not completed the one it was then building. Desperate to control the epidemic, Hamburg worked 24 hours a day to finish its filtration plant. Although the filter went into operation a year ahead of schedule, the damage had been done.

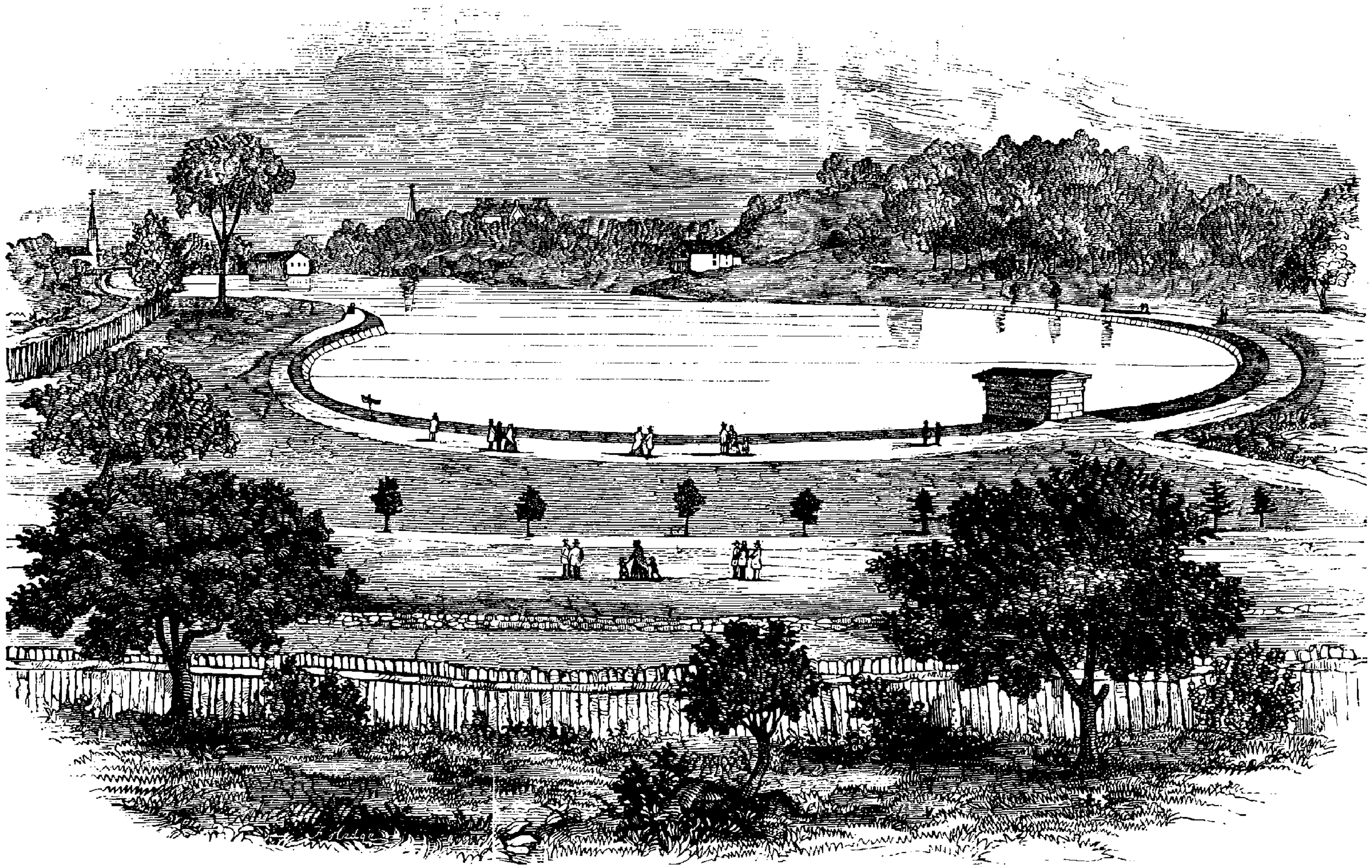
In the United States, it was realized at last that the invisible animalcules which Nathan Hale had recommended be ignored were indeed significant. High counts of colon bacillus, itself harmless, began to be taken as presumptive evidence of contamination by sewage. This practice is continued today. Newark, which had a mortality rate from typhoid fever of over 100 per hundred thousand, switched to an upstream source with a lower coliform count and the city's mortality rate declined to 20. Paterson, New Jersey reduced its typhoid mortality rate from 30 to 15 per hundred thousand by filtering its water.

Philadelphia, which had a typhoid mortality rate fluctuating between 35 and 70 per hundred thousand, procrastinated until 1902 before constructing filtration plants. It did not filter its whole system, however, and in 1906 the rate went up to over 80. By 1911, the whole system was filtered, and typhoid was finally brought under control.

Mortality from typhoid fever, of course, is now practically zero. During the decade from 1880 to 1889, the average annual mortality in cities was about 58 deaths per hundred thousand. By 1910, it had dropped to 20, and by 1938 to 0.67. While this dramatic reduction cannot entirely be ascribed to protection of water supplies, the management of water supplies was instrumental in producing this improvement.

The use of chlorine for disinfection was not introduced until the twentieth century. Its first application was in England in 1904, when Sir Alexander Hamilton used hypochlorite (essentially bleaching powder) to disinfect water as it entered the London distribution system. In 1908, the Jersey City Water Company proposed to fulfill its obligation to provide pure water to the city by the use of chlorination. The law suit which resulted finally proved that chlorination produces bacteriologically safe water. Poughkeepsie, New York, which had been a pioneer in the field of filtration, was among the first to use chlorination. In February 1909, they instituted a process using chloride of lime. Philadelphia came next, in September of the same year. In 1912, Philadelphia switched to the solution feed process now commonly in use. By use of a regulating chlorinator, chlorine gas is dissolved in a minor stream of water which is mixed with the major stream before it leaves the treatment plant. By early 1941, over 85% of the 5,372 water works in the United States providing any treatment used chlorination. Disinfection by ozone, popular in France, was tried in several systems in this country and is still in use in a few cities. Ozonation has several advantages over chlorine: it has higher germicidal power, its potency is unaffected by pH or ammonia content, and it leaves no taste in the water. However, ozonation is not widely used today because of its high capital costs and because it lacks residual disinfection capability, an issue which will be discussed presently.

The Reservoir at Brookline, Massachusetts, Early 1900's



A Modern Water Supply System

A modern water supply system has three major parts which are related to recreational use: a supply source, treatment works and an organization to operate the system. The fourth major component, the distribution network, does not concern us here.

The Supply Source

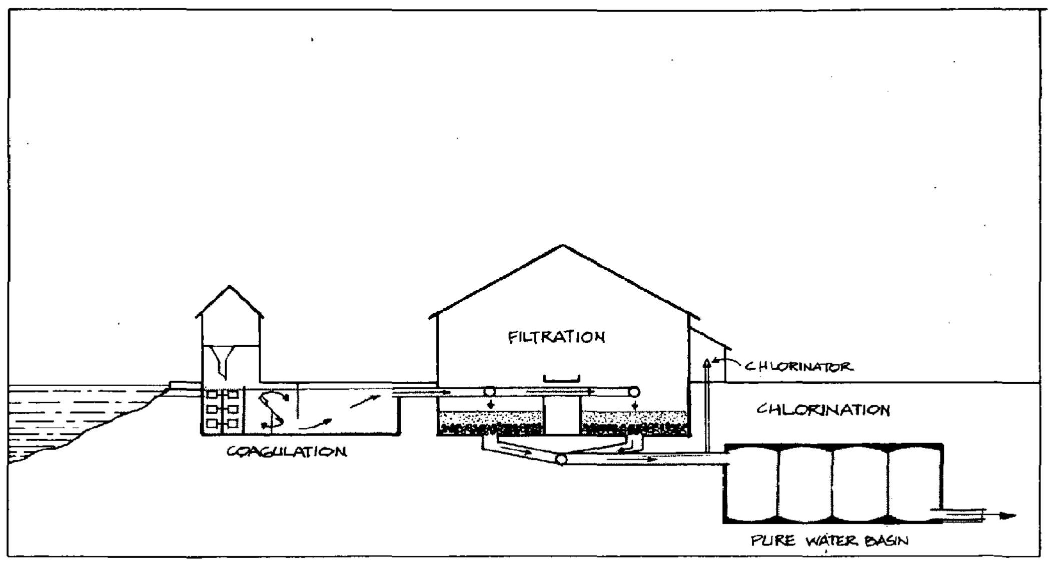
A modern water system which uses surface water may have as many as three separate types of reservoirs.

Upstream reservoirs, usually called collection or storage reservoirs, are the major source of supply. Rainwater falling on the watershed flows into streams which in turn flow into the collection reservoir. In the Northeast, most collection reservoirs are man-made impoundments.

From the collection reservoir, the water flows through an aqueduct to a terminal reservoir which is generally smaller than a collection reservoir. Here, several days' supply is held and allowed to settle before it is treated.

After treatment, water is sometimes put in distribution or balancing reservoirs to facilitate the maintenance of even flow throughout the system. Commonly these hold from a few hours to several days supply at normal rates of use. While not always necessary, distribution reservoirs are useful for maintaining pressure in the pipes and form a margin of safety against temporary interruption of flow from the treatment plant. In case of fire, distribution reservoirs provide an immediately available reserve. They are usually artificial structures and are frequently covered to protect the finished water.

Schematic Representation of a Modern Water Treatment Plant, Showing Coagulation/Sedimentation, Rapid Sand Filtration, and Chlorination



Protecting Water Quality

Treatment varies in intensity in a modern system according to the quality of the "raw" water entering the treatment plant. In 1934, the American Water Works Association adopted the position that, although watershed management and protection of the reservoir was the "first line of defense" against contamination, some form of treatment is also required. Some major water quality management techniques are discussed below. Appendix I of this handbook gives a more complete presentation of water treatment techniques and their effectiveness in removing contaminants related to recreational use of water supply reservoirs. In addition to these techniques, there are many types of water treatment designed to deal with specific contaminants found in some localities. The accompanying drawing depicts a typical type of water treatment plant.

Watershed Management Watershed management is the first line of defense against contamination of the water supply. It is also, in theory, the best. By maintaining adequate vegetative cover on the watershed to prevent siltation, and by preventing pollutants from entering tributary streams, reservoir water can be kept at a high level of quality. Natural purification processes are allowed to work to the public's best advantage.

Perfect watershed management would require that the water company have complete jurisdiction over the entire watershed, for any development can cause a variety of contaminants, including industrial wastes, household sewage, lead from auto exhaust, and highway deicing salts to enter the reservoir water. In Seattle, the city's watersheds are completely closed to the public. About one-quarter of the land area of King County, or 450 square miles, consists of restricted and undeveloped municipal watersheds. Elsewhere, such as in the Northeast, such near perfect control is not possible. In some states, new laws have been proposed to give the state more authority to control development on watershed land not owned by water companies, but even with such laws, control will not equal that available to a city like Seattle.

Even total isolation of a watershed cannot assure that the water will not receive some contamination. Groundwater feeding reservoir springs may originate outside the watershed and carry viruses and other contaminants. The settling of air pollutants on the watershed may contribute toxic substances to the reservoir water. Animals and birds may carry in diseases to which man is susceptible.

While watershed management must continue to be an integral part of water supply technology, its limitations are becoming more evident. Because perfect control is impossible, watershed management cannot function as the only safeguard but must be used in conjunction with water purification processes.

Chlorination The prime purpose of chlorination is disinfection, meaning the destruction of pathogenic organisms. Although filtration can physically remove much bacterial contamination from water, it cannot alone provide assurance of a hygienically safe supply. Chlorine, by attacking the enzyme structure of living cells, destroys microorganisms. At a greater concentration, at least one milligram per liter for 30 minutes or more, it also inactivates pathogenic viruses.

When chlorine is introduced into water, a certain amount will undergo side reactions with chemical components in the water that inactivate it. To ensure disinfection enough chlorine must be added to satisfy this "chlorine demand" and to leave additional active "residual chlorine." Adequacy of disinfection is indicated by the presence of an established "residual chlorine" at the end of a specified contact period.

Because it is difficult for chlorine or any disinfectant to destroy microbes that are protected by being imbedded in particulate material, disinfection is most effective in conjunction with filtration. Addition of the chlorine before filtration provides extra contact time for disinfection and helps to keep the filter beds free of microbial growth.

Other processes are sometimes used for disinfection, notably ozone, which is popular in parts of Europe and Canada. While ozone is a more powerful disinfectant, it lacks one property which makes chlorine particularly useful. After both the initial demand and the disinfection demand are satisfied, the water will contain active residual chlorine as it enters the distribution system. Some forms of residual chlorine give chlorinated water its characteristic taste and odor. The residual chlorine serves to protect the water against additional contamination it might encounter in the distribution system. Also, its presence acts as a signal to water quality monitors. If the residual chlorine is not present when the water reaches the household tap, then it has been absorbed by contamination somewhere in the pipes, and some sort of failure in the system may have taken place. The residual chlorine also performs the important service of inhibiting the growth of slime in the distribution system.

Most bacteria do not require more than a few minutes with the usual chlorine residual for disinfection to take place. Some viruses, however, are more resistant. In their case, further contact with the residual chlorine as it flows through the pipes is useful, for, if any have survived the treatment plant, they can be destroyed during distribution.

However, the chlorine residual maintained in the water is not enough to protect against a failure in the system which involves any substantial contamination. Leakage of substantial sewage waters into the pipes would overwhelm the residual chlorine immediately.

There are two major forms of chlorination practice. The simpler technique, called "plain chlorination," is to add to the water the minimum dosage of chlorine that will leave a set residual chlorine in the finished water as it leaves the plant, generally a few tenths of a milligram per liter. No attempt is made to ensure any particular form of active chlorine. Provided the need for disinfection is simply to guard against the possibility of minor occasional contamination, this procedure may function quite satisfactorily.

The more complex, more technically sound practice, designated "free residual chlorination," is to add sufficient chlorine not only to satisfy the normal chlorine demand but also to eliminate combined forms of chlorine, leaving a residual that is the highly active "free chlorine" capable of destroying chronic viral as well as bacterial contamination. Satisfactory performance of "free residual chorination" requires careful monitoring and control of the chlorine dose to adjust for changes in the quality of raw water. It should be used, however, whenever there is continuous contamination of the raw water supply.

Recently, some questions have arisen about the practice of chlorination. Under some circumstances, chlorine can react with organic compounds in the water to form chlorinated hydrocarbons which are thought to be carcinogenic. This problem has been observed primarily as the result of chlorine disinfection of municipal waste treatment plant effluents. It is not thought to result from chlorination of drinking water supplies, particularly if the systems use high quality reservoir water. Furthermore, several of the advanced filtration techniques described below are capable of removing these carbon based compounds. The Environmental Protection Agency is undertaking a major study to determine whether the interaction of chlorine and hydrocarbons does in fact represent a public health problem and, if so, what should be done to solve it.

Filtration The purpose of filtration is to reduce turbidity and color and to remove the major portion of the bacteria load. Filtration, unlike chorination, is not always performed in treatment of drinking water. Although highly recommended, filtration is sometimes omitted where the raw water supply is judged pure and clear.

The most frequently used filtration technique is rapid filtration. This process includes addition of a coagulant, such as alum, to the water before filtration. The coagulant creates a floc which helps settle out color, turbidity, and other impurities. The water is then filtered to remove fine floc particles and substantial amounts of bacteria. Filtering is a complicated biological and chemical process which involves much more than a mechanical screening of particles.

Slow filtration plants, as their name implies, process less water per acre per hour than rapid filtration plants. Their advantage is relative ease of operation, but they are seldom installed in new systems today because of their higher costs.

Filtration will probably become increasingly widespread in the near future. The new United States Environmental Protection Agency drinking water standards, issued in 1975, call for a reduction of turbidity to one-fifth the currently accepted level. Almost every surface water supply not currently filtering its water will be obliged to do so to be in compliance with the new standards.

Other Filtration Processes In some cases, for reasons of efficiency in the handling of large volumes of water or where the raw water source is of unusually poor quality, more intensive treatment techniques are used. Two common techniques are anthracite coal filters in conjunction with sand filters and granular activated carbon beds after conventional filtering. Coal sand filters are typically used to remove heavy loads of suspended solids. Activated carbon is extremely effective in removing tastes and odors, and is also effective in removing organic compounds. Both processes permit the use of smaller filter beds rather than traditional sand techniques alone. In recent years the cost of activated carbon has declined significantly, making advanced filtration processes economically attractive. However, with the exception of a small number of new treatment plants, these techniques are not widely used at present.

pH Adjustment Adjustment of the pH of water is sometimes necessary. Highly acidic water can corrode the distribution system and the treatment plant machinery and, where lead pipes are still in use, excess acidity can form poisonous salts in the distribution system.

Carbonate alkalinity, common in hard waters, inhibits corrosion. Reduction of acidity is achieved by increasing carbonate alkalinity.

Water Supply Organizations

In the Northeast, four major types of agencies own water supply reservoirs: public agencies, private water companies, regional water districts, and cooperatives.

Most suppliers are public agencies, serving only a single town, but there are numerous private water companies in the region as well. Public water departments which serve a single municipality are usually an agency of the government like the school or highway departments. Although they collect revenues from water users, their budgets are usually authorized by the municipal government authority, and any increased costs which recreation might incur could be covered through increased budget authorization and by the methods described later in the handbook.

Private water companies, like investor-owned electric or gas utilities, are generally chartered by the state or municipal government and operate under their jurisdiction. Private water companies, like any private corporation, respond to the profit motive, and, therefore, would tend to favor recreation if it could pay its own way or make a profit. On the other hand, these companies are aware of their special position in the community. Like other private utilities such as the telephone company, they have been granted a local monopoly in order to provide cheap and efficient service. To protect their privilege they are anxious to avoid controversial policies and would want a majority of the community in favor of recreation before they would allow it. Once persuaded that recreation would be popular, they might be willing to bear some or all of the costs as a public relations expense.

Water districts and other regional suppliers (like Boston's and Hartford's Metropolitan District Commissions) are less numerous but serve several of the region's major metropolitan areas. Regional agencies are usually established under state enabling legislation to achieve effective management of water resources at low cost. The idea of a water district is said to have originated in Maine, when a country lawyer missed the last train home: he walked through adjacent communities on his way to Waterville and realized they formed a natural grouping for the purpose of public water supply.

Regional water districts are apt to lie somewhere between municipal suppliers and private water companies in their response to expanded recreation. They are public agencies, so their authority can be reached by the general public. But, if their jurisdiction includes several municipalities, they can be isolated from the wishes of any one locality. Likewise, budget authority is likely to be beyond the control of any single locality so recovery of recreation costs may be an important issue. If the regional agency also provides recreation, the problems may be eased somewhat.

Cooperatives, like dairy and other agricultural cooperatives, are formed out of common need. In the Northeast, most water supply cooperatives exist in rural areas and are quite small. There are only a few water supply cooperatives in the region.

Water Treatment and Recreational Use

Historically, body contact with drinking water has been rigidly proscribed at the major reservoirs of the Northeast. Despite advances in water treatment technology, these restrictions are still in effect. The idea that treatment is an expensive nuisance has not entirely died out despite recommendations from health departments and water supply experts that drinking water from surface sources should be both filtered and chlorinated before use.

In the Northeast, as in the rest of the country, virtually all water supplies are chlorinated. Relatively few systems which use reservoirs as their supply source have installed filtration plants, however.

Elsewhere in the United States circumstances were different. Many new water systems were built in the 1930's. By that time, a great deal more was known about water treatment than when the first water supply systems were constructed in the Northeast. In the more arid areas of the country, large water supply reservoirs provided the best, and sometimes the only, water for recreation. Since the water impounded in these reservoirs was often not of the same high quality as that found in the wooded watersheds of New England, both filtration and chlorination were provided as a matter of course. In such a situation it was logical to allow recreation on the new reservoirs, for recreation would place only an imperceptible additional treatment load on the high-quality treatment plants and would not affect the quality of the finished water.

In Illinois, for instance, water supply reservoirs generally are available for recreational use. The reservoir serving Springfield has two swimming beaches, hiking trails, a wildlife sanctuary, a scout camp, and a yacht club. In Indiana, the privately owned Muncie Reservoir has been leased to the city for 60 years for a nominal fee of $10 in order to provide golfing, swimming, fishing, skating, and ice boating. Similarly, multiple use has been general practice in Kansas, Oklahoma, Utah, and many other states. The reservoirs serving Wichita Falls, Texas even allow commercial fishing in addition to boating, swimming, sailing, and other activities. Although several states have restrictions against swimming, few prohibit boating and fishing.

Today we see two contrary attitudes toward recreation on water supply reservoirs. In the Midwest, West, and South, recreation has been instituted as a matter of course in conjunction with full-scale treatment. Water managers accept supervision of recreation as part of their basic responsibility. Since the population of these states never experienced the horrors which plagued early public water supplies during the seventeenth and eighteenth centuries, the people do not feel threatened by multiple use of their reservoirs.

In the Northeast,[5] exactly the opposite is true. Epidemics were repeatedly shown to be the result of water contamination by human wastes, so every effort was made to isolate supplies from human contact. Considerable shoreline was available elsewhere for recreation, and water managers saw no reason to open their properties to increased public use.

Circumstances in the Northeast have changed. New toxic substances have been introduced into the environment which make reliance on watershed protection to insure high water quality obsolete. More advanced treatment is now required to provide safe drinking water. At the same time, development has consumed much of the available shoreline, encroached on former wilderness areas, and has limited the recreational opportunities available to an expanding urban population. Recreational opportunities for the poor and aged in particular have been reduced as the result of urban development and water pollution. With provision of treatment required by our contemporary understanding of the problems of safe water supply, all forms of recreation would be possible at water supply reservoirs.

Water managers in the Northeast are still generally opposed to multiple use of water supply reservoirs. They believe that increased public recreation on the lands and reservoirs they manage will degrade water supply. They feel watershed protection with minimal treatment is adequate to protect the public health. To institute recreation would require them to relinquish a valued tradition and assume new responsibilities. To date there has been little incentive for water supply managers to favor increased recreation.

As it becomes clear that higher levels of treatment ought to become standard even at protected reservoirs, more recreation opportunities will open up. They will be a valuable side benefit to the installation of more filtration plants and to the more careful monitoring of drinking water quality.

Recreation on reservoirs is not an all or nothing matter; restrictions on some forms of recreation may be entirely appropriate, depending on the local conditions. Types of restrictions and the attitudes of water managers in the Northeast are examined below. This section concludes with descriptions of successful recreation at four reservoirs in the Northeast.

Types of Recreation Policies

Total Restriction Total restriction of recreational activities is essential at distribution reservoirs, whose water will receive no more treatment. Any pollution would flow directly to consumers. These reservoirs should be covered to protect them from all sources of pollution.

In the Northeast, recreation is also generally restricted at terminal and collection reservoirs. At terminal reservoirs it is argued that total prohibition is easier to administer than a program to keep recreational uses within safe limits. Terminal reservoirs tend to be close to urban areas, where use would be substantial, and they are generally too small to permit reliance on natural processes to destroy contamination. In cases where the only treatment available is chlorination, some water managers believe recreation constitutes too great a risk.

Recreation is prohibited at many major collection reservoirs as well. The most common explanation for this policy is the lack of adequate water treatment, but such a policy is extreme. The large size of most collection reservoirs allows for considerable purification of the water by natural means. They usually are far enough from centers of population so that the level of recreational use could be readily controlled.

Where complete water treatment (filtration and chlorination) is available, the policy of total restriction on recreation needs thorough reexamination.

Partial Restriction Most reservoirs limit recreation to some degree. In the Northeast, swimming is almost universally prohibited. It is also very common to find restrictions against boating and often against fishing. Hunting, hiking, snowmobiling, picnicking, and riding are among other activities restricted at various sites.

Partial restrictions make sense as a general policy since, except at the very largest reservoirs, all forms of recreation can not be made compatible with one another. The degree of the restrictions should be reasonable, however. Aside from the technical requirements of protecting the water supply from unwanted contamination, managers often find justification for extensive restrictions on recreation in their answers to the following questions:

Do the costs of supervision of a particular form of recreation outweigh the benefits in terms of user revenues of public goodwill?

Is there a demand for this kind of recreation?

Would permitting the recreation offend any water users?

Are there any side-effects of this recreation activity which are dangerous to water quality?

In many cases, water managers do not feel the benefits of providing a particular kind of recreation are worth the costs. Many are conscious that the public would like to see recreation expanded but feel that the public would not be willing to pay the costs, and that public gratitude is not sufficient to justify the additional responsibility entailed. Although general sightseeing and other low intensity activities may require almost no expenditure of funds, many water managers feel that collecting the refuse from picnickers, or buying boats to rent, would represent unjustified inconvience, responsibility and expense.

Closely allied in the minds of water managers is the question of demand. They feel the public would not actually use facilities as much as recreation advocates claim. For most recreation facilities, demand will increase over time. A water company may open a picnic area, find that few use it, and close it after a short time before many people become aware of it. Good planning is crucial to encourage use. A poorly designed recreation area can discourage use even though it costs just as much as a well designed one.

Some recreational activities, especially swimming, may be offensive to some water users, and managers are justifiably anxious not to alienate their clients. In areas of the country where swimming has never been allowed on reservoirs, some people are repulsed at the idea, despite the fact that uncontrolled illegal swimming regularly occurs. In areas of the country where swimming has always been allowed, people are perfectly accustomed to it. In areas where objections of this sort have been voiced, it may be desirable to phase in new recreation gradually. Contemplating the change from restriction to permission is emotionally difficult for a small minority of the public, but familiarity seems to lead to acceptance.

Dealing with the side effects of recreation is an important issue to water managers. Often the recreation itself may be acceptable but activities which accompany the recreation may be undesirable. Public abuse of recreational facilities is an unfortunate reality.

Other secondary effects of recreation can include destruction of vegetation and littering. While none of these constitute a serious health hazard, they do indicate substandard reservoir management. Maintaining a high standard involves considerable expense. Unless funds are available to maintain recreation areas properly, the littering problem is a powerful argument against expansion of recreation at reservoir areas.

Minimal Restriction Some areas are large enough to sustain virtually unrestricted recreation, including swimming, boating, fishing, and all manner of adjacent activities. At present, no artificial reservoirs in the Northeast have such a policy. Sebago Lake in Maine is unique in the region in its tradition of open recreation. Many artificial reservoirs could sustain virtually unrestricted recreation without hazard to the water supply, but the decision to open them would require a major change in accepted policy.

The only restriction necessary for protection of the reservoir in such a situation is to cordon off a radius around the water intake. A two mile radius such as at Sebago Lake would be appropriate with minimum water treatment (chlorination). With complete treatment, the restricted area could be smaller. Policing of the reservoir would be necessary, and in heavily populated areas this could involve significant costs. But, if the public is willing to accept such costs, there are many reservoirs at which large scale recreation could be instituted.

Reservoir Recreation Case Studies: Reservoirs in the Northeast

In the Northeast, as well as in other parts of the United States and the rest of the world, there has been considerable experience with various types of recreational activities at water supply reservoirs. Examples of recreation permitted at four Northeastern reservoirs are presented below to describe a range of possible recreation policies.

Case Study:
Fresh Pond Reservation
Cambridge, Massachusetts

Fresh Pond is a terminal reservoir serving Cambridge, Massachusetts. Its treatment plant includes facilities for coagulation, filtration, and chlorination. Access to the pond is prevented by an eight-foot chain link fence around its 2.5 mile circumference. Just outside the fence but within a few feet of the water is a paved road wide enough for the passage of a patrol vehicle. Well-kept lawns and woods surround the treatment plant. The park facilities include trash receptacles at a few convenient locations and a small children's play area with one set of swings, a slide, and a climbing gym. At an elevation of about 30 feet above the water are two semicircular terrace outlooks, and at another attractive site there is a group of park benches overlooking the water. The grounds are carefully maintained by the Cambridge Water Department. A parking lot serving the facility holds approximately 150 cars when fully crowded. The site is open from dawn to dusk year-round.

In 1932, the State Legislature passed an Act enabling the establishment of a municipal golf course on Water Department land. The course lies to the west of the reservoir and is furnished with a complete drainage system connected to the city sewers.

According to the manager of the treatment plant, his first purpose in caring for the reservation is to maintain high standards of watershed management. The public's use of the park is secondary, but he is pleased that the public uses it as much as it does.

Activities at the park are various. The circuit road, built primarily for inspection of the grounds, is used as a promenade, a bicycle path, and a running track. Its ten foot width allows multiple use without conflict between walkers and runners, though bicycles are constrained to a slow pace when the road is crowded. The lawns are used for picnicking, informal games, sunbathing, and for exercising dogs. Because users tend to live close by, the lack of toilet facilities is not inconvenient.

According to the manager, a tenfold increase in use over the past twenty years has not noticeably damaged the grounds and water. He attributes this in large part to efficient police patrol. In addition, frequent users of the park are likely to report abuses of the facilities directly to the Water Department personnel. He feels that the public has a high sense of responsibility about the grounds and that only a small minority abuse the facility.

Foremost among the maintenance problems is the integrity of the fence which protects the water. Although mended two to three times per month, it is broken through again within a day or two of repair. In the summer there is surreptitious swimming, and fishermen use the reservoir illegally during the spring, summer and fall. Dogs easily reach the water year-round. Although the manager disapproves of swimming and fishing in terminal reservoirs as a general principal, he tolerates this comparatively low level of abuse. While additional recreational use could be supported by the treatment the water receives, the shore is quite steep and rocky. New facilities would be required for boating, fishing or swimming, and the level of management required would be higher.

Fresh Pond Reservation is an example of a very successful user-oriented recreation facility at a terminal reservoir. Its success is predicated on the adequate provision of high quality water treatment, on the simplicity of its recreational facilities, and on the attitudes of the people who use it.

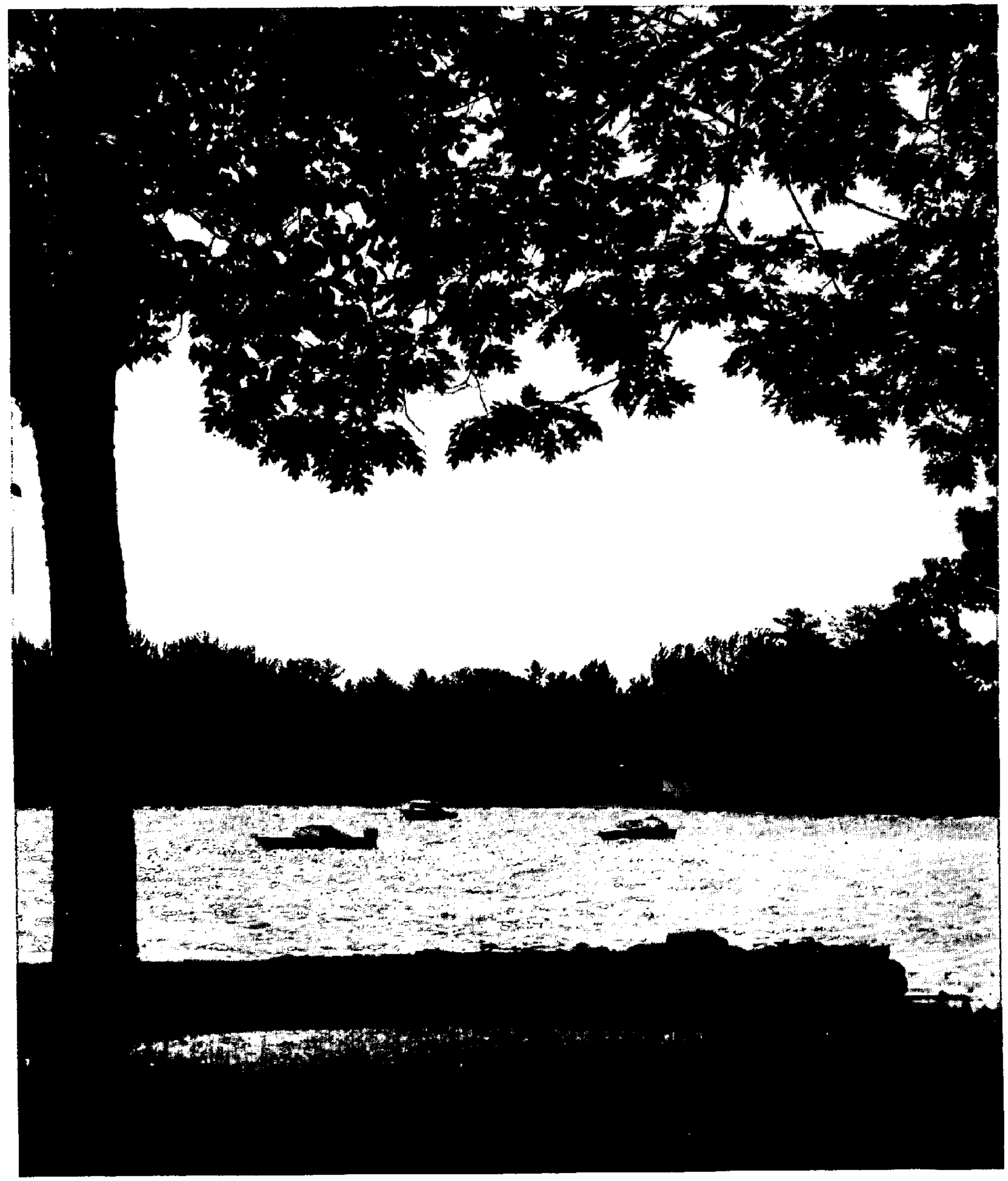
Case Study:
Quabbin Reservoir
Petersham, Massachusetts

Quabbin Reservoir, completed in 1939, was the result of an enormous water engineering project. Two rivers (the Swift and the Ware) were impounded, four towns were obliterated, and the boundaries of two others were changed. Its 118 square miles of shoreline encompass 39 square miles of water containing 60 islands totaling 3,500 acres. Seven years were required to fill Quabbin's storage capacity of 412 billion gallons. Quabbin provides 116.8 billion gallons per year to serve two million people in 34 Eastern Massachusetts cities and towns, including Boston. Water from Quabbin Reservoir flows through two major reservoirs and several smaller ones on its 60 mile journey to Boston. The entire system is operated by the Metropolitan District Commission, a state agency established to coordinate regional services in Boston and Eastern Massachusetts.

Despite Quabbin's impressive size, recreation on it is minimal. Limited fishing is allowed both on shore and from boats, which are available at three rental areas. Fishermen may bring their own boats provided the motors are less than ten horsepower. Some picnic areas are provided, as well as toilet facilities, an observation tower, and marked hiking trails. No swimming is allowed because it is against Massachusetts law. Also prohibited are wading, fires, trail bikes, hunting, trapping, sailboats, canoes, and the launching or landing of boats except in designated mooring areas.

The water from Quabbin is given minimal treatment — simple chorination — just as in Sebago Lake in Maine with its extensive recreation. Clearly, more extensive recreation would not be a threat to public health. Why then is it not allowed?

The legislation authorizing the construction of Quabbin specified the present level of recreation. The Metropolitan District Commission has always followed a policy of going as far afield as necessary to obtain water

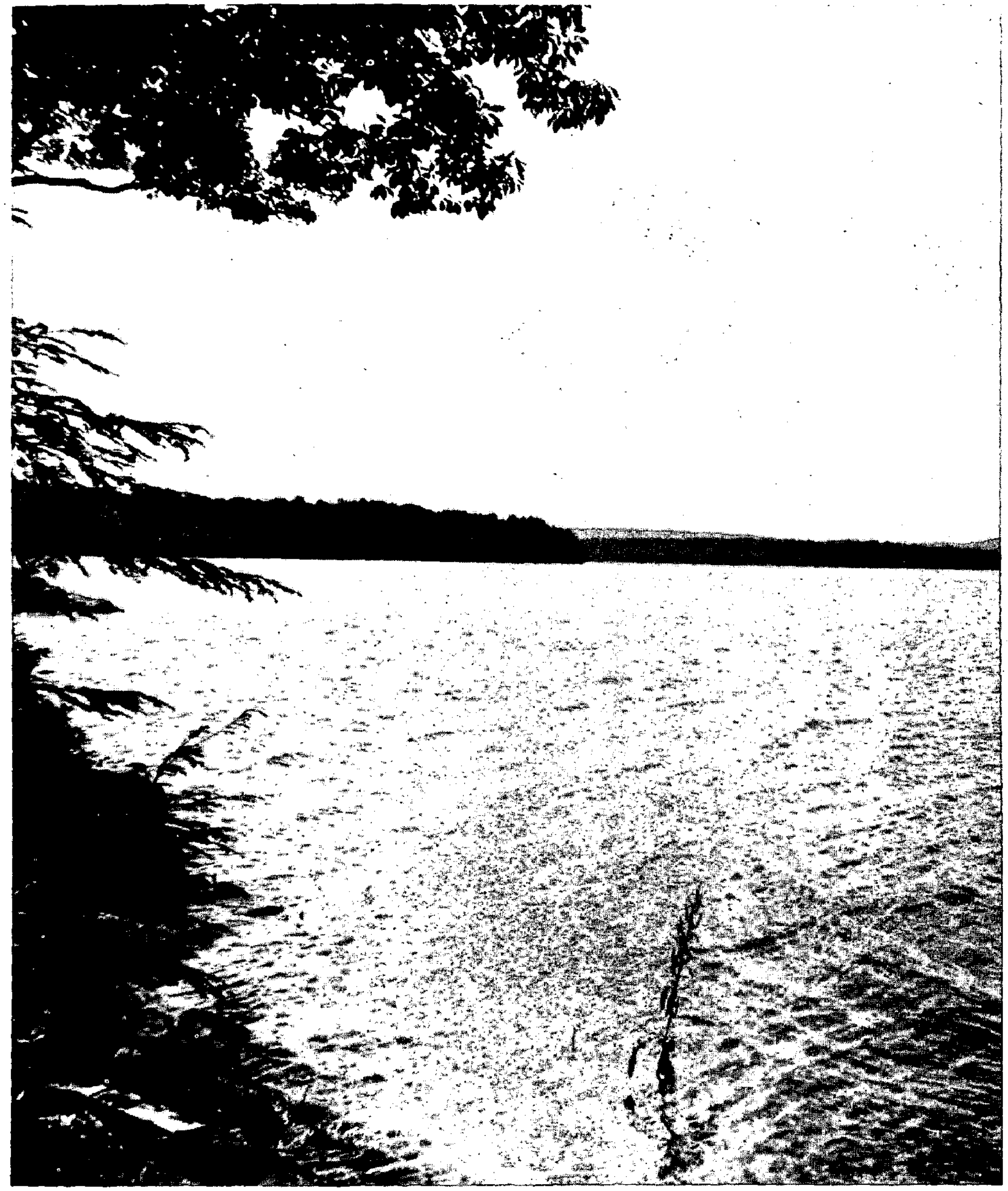


Sebago Lake: Water Supply Source for Portland, Me. Sebago has long providec a wide range of recreational opportunities.

Fresh Pond Reservoir: Terminal Reservoir, Cambridge, Mass. Fresh Pond is a popular local recreation site as well as a protected reservoir.

Quabbin Reservoir: Water Supply Source for Boston, Mass. Despite its large size, recreation at Quabbin is strictly limited.

Credit: Metropolitan District Commission



Pequannock Watershed Reservoir:
Water Supply Source for Newark, N.J.
A new policy is opening up Newark's
reservoirs to extensive recreation.

which does not require filtration. By building Quabbin, this objective was achieved. Public pressure was largely responsible for the level of recreation which does exist. Without such pressure and the consequent legislation, Quabbin might have been operated as Scituate Reservoir in Rhode Island is today, where no recreation is allowed at all.

In defense of the limited recreation is the unique quality of the reservoir itself. Quabbin is by far the largest artificial impoundment in the area and possesses a natural beauty which could not be duplicated. The low intensity recreation it provides has considerable merit; more intense use might drive away the abundant wildlife and change its character. On the other hand, Quabbin is sufficiently far from major cities so that it might not face excessive pressures if regulations were relaxed.

Because of its large size, any type of recreation, including body contact activities, could be permitted at Quabbin. Quabbin could be opened for sailboats, boats, canoes, and rowboats without great problems. More mooring facilities would probably need to be constructed, but these could be made self supporting through user fees. A swimming beach could be maintained. The Quabbin watershed supports a large number of deer and upland birds. Selective or unrestricted hunting could be permitted on the surrounding lands.

The lack of filtration capability in the MDC system is an obstacle to recreation on all its reservoirs. The cost of filtering all its water would be significant, but the margin of safety without filtration is getting progressively thinner. Quabbin is a typical case of a major reservoir with excessive restrictions. With or without more treatment, there is opportunity for greater public use of this area. How much more recreation should be allowed is an open question — Quabbin's unique resources as a semi-wilderness area should not be disturbed.

Case Study:
Pequannock Watershed
Newark, New Jersey

The Pequannock Watershed is one of the three major water supply sources of Newark, New Jersey. Plans for relaxing the traditional restrictive policies on the recreational uses of this valuable resource are currently underway. The watershed lies 35 miles from the center of Newark and contains approximately 64 square miles. The reservoirs in the watershed produce an estimated yield of about 55 million gallons per day.

The watershed lands were first settled by Algonquin Indians who maintained hunting and fishing rights until the 19th Century, long after Europeans had moved into the area. In 1715, Dutch farmers founded Rockaway in the watershed lands. The region expanded around a diversified agricultural base which included wheat, corn, rye, lumber, and naval stores. The ample soft water in the area encouraged an extensive leather tanning industry.

In 1765, iron production was started in the watershed. The vast amounts of water, hardwoods for charcoal, and accessible ores provided the raw materials for meeting the expanding demand for iron in the American colonies. By the early 1900's, however, iron production had largely ceased.

On this history of intensive human use, water supply in the Pequannock Watershed was developed. In 1889, after a lengthy political wrangle, Newark contracted with the East Jersey Water Company to build three reservoirs with the watershed and an aqueduct to Newark. From that time to the present, the system was gradually expanded. Now there are five water supply reservoirs and several other lakes in the watershed. The City of Newark owns 86 percent of the watershed or about 35,000 acres.

Water is collected in Oak Ridge Reservoir (482 acres), Clinton Reservoir (423 acres), Canistear Reservoir (350 acres), and Echo Lake Reservoir (300 acres) and flows into the lowest reservoir on the Pequannock River, Charlotteburg Reservoir (375 acres). Chlorine and lime are added to the water before it is transmitted to the terminal reservoir, Cedar Grove Reservoir (100 acres), located on a mountain above Montclair. Chlorine is added to the Cedar Grove water to maintain a free residual in the distribution system. Newark is under mandate from the State of New Jersey to construct a filtration plant for the water from this supply system.

Traditionally only very limited recreational activities have been permitted in the watershed. Several towns operate small municipal parks at the fringes of the watershed, but the reservoirs and streams have been closed to the general public for fishing and boating, and camping has been discouraged. Swimming, horseback riding, skating and other activities are specifically forbidden. Access for any reason has been allowed only by special permit, and a five-man continuous patrol is maintained to enforce the regulations.

But for several reasons, these policies are changing. In Northern New Jersey, recreational opportunities are in very short supply. At the same time, the population of the area is growing and exerting even greater pressure on the existing sites. The watershed also represents a significant financing burden to Newark, which must pay nearly $1 million yearly in property taxes to the towns of the watershed.

In May 1971, Newark's Mayor Gibson initiated a study of the potential uses of the Pequannock watershed's lands and waters. The study concluded that more intensive recreational development would be compatible with providing high quality drinking water and conserving the natural beauty of the area as well. It advocated a policy of multiple use and protective development. As a result, new recreation opportunities were recommended, including swimming, fishing, boating, ice skating, nature trails, hiking, team sports, camping and an amphitheater. Some of these activities were implemented during the summer of 1974. A non-profit public corporation, the Newark Watershed Conservation and Development Corporation, was created to plan and administer the development of the Pequannock Watershed. User charges levied on recreational activities are to go toward reducing the watershed property taxes.

This case study provides a good example of increasing the recreational uses of water supply reservoirs. Recreation at an upland collection reservoir with free residual chlorination is being expanded in consonance with public health objectives. The addition of the planned filtration plant will further protect public health and expand the opportunity for recreation in the downstream reservoirs. The development will help defray the enormous costs of maintaining compatible land uses in the watershed. An innovative institutional arrangement has been established to implement the program. The people of Newark and others throughout Northern New Jersey will benefit from this revised recreation policy. Those planning for more extensive recreational uses of water supply reservoirs can benefit from Newark's experience.

Case Study:
Sebago Lake
Sebago, Maine

Sebago Lake is a natural lake, not an artificial reservoir, but it is used by Portland, Maine for its water supply. There has always been recreational use. When Portland began to take its water from the lake, no effort was made to restrict recreational activities except to establish a radius around the water intake within which no recreation is permitted.

The lake covers 46 square miles and holds 3 million acre feet of water. Sebago's watershed area is 400 square miles, and its shoreline is about 50 miles. The lake is very deep, reaching 308 feet at its deepest point. Within two hundred feet of the water are some 1,600 homes, and the total reaches 3,500 if housing further back from the water is included. Other recreational facilities include resorts, camps, camping areas, motels, lodges, guest houses, marinas, landings, and picnic areas. There are no restrictions on boat sizes or engine power on the lake, though boats are prohibited from having on-board toilets of any kind.

The safety radius around the intake, which lies about 1,600 feet out into the lake, is marked by on-shore markers and buoys. Access to the water department land is somewhat restricted, though the managers do not worry about pedestrian use of their land. The land is posted against snowmobiling, but effective control of them has proved to be impossible.

During the summer the lake is supervised by four Water District employees, one in a boat, two on shore, and one analyst to record water quality. They inspect the operation of septic tanks, which operate under no stricter regulations than the state sanitary codes. Despite the intense recreational use of the lake, the water quality is very high. Average coliform levels for Sebago are presented in Figure 1.

Samples taken in October of 1974 show no degradation from these levels. Within the two mile limits, many

Figure 1
Sebago Lake Coliform Counts

Location	Average Coliform/100 ml*
Tributaries	315
Recreation Areas	168
Within Protected Intake Radius	16.7
At Intakes	5

*Based on 15,000 samples taken over 11 years

Source: Robert P. Grady, "The Effect of Recreational Use on the Quality of Sebago Lake Water," *Journal of the New England Water Works Association*, Volume 86, No. 2., June 1972.

samples with zero coliform count are found; the rest are less than 5 coliform per 100 ml. The only treatment given the water is light chlorination. The Portland Water District has received authority from the State Legislature to require the sewering of all developments on the lake but has not used this power and does not foresee the necessity to do so at this time.

Sebago should not be taken as characteristic of conditions which could prevail at all large reservoirs in New England. Its depth is greater than that of artificial impoundments, providing great dilution and a long residence time to counteract possible contamination. Its watershed is not subject to the same urban pressures common to other areas. Nevertheless, large artificial impoundments can sustain much greater levels of recreation than they do currently, even with free residual chlorination as the only water treatment.

The Case for Increased Recreation

"All land is watershed, in addition to whatever else we may use it for."[6]

It is no longer possible to reserve whole watersheds simply for the production of drinking water - there are too many competing demands on the land near urban areas. Today land must serve multiple purposes. Further, the notion that we can perfectly protect a watershed from all contamination simply is not true. Once these facts are accepted, the problem of planning compatible land uses for watersheds must be faced.

Properly managed recreation is one of the most appropriate uses for watershed land. It requires no extensive building, no major paving of the ground, and the pollutants and/or contaminants produced are limited and treatable. At the same time, it yields many public benefits, including physical and mental benefits to participants and economic benefits to the community in the form of expenditures for sporting goods and higher adjacent land values. But reservoir recreation cannot be managed as if it were only a question of economics or systems management:

". . .in multi-purpose reservoir management, the major costs are for water quality and public safety, and the major benefits are to the public utility. This observation is not put forth to deny the importance of monetary costs and benefits in reservoir management, but rather to affirm the greater importance of providing for public needs and health protection."[7]

In other words, profit should not be the sole guiding motive for increased recreation. While this seems to be an obvious point, its implications are significant. It means that the level of recreation provided does not have to coincide with the level which the "market" would desire. Recreational activities may be set below the market demand, as they traditionally have been, if it is decided that to meet the demand would pose a threat to public health. Recreation facilities may also be provided in excess of the public demand, in order to provide opportunities to people who have no other source of recreation, or in order to provide experiences which are special or unique. In this sense, recreation may be seen as merit good, such as a public library, which should be provided even if it cannot pay its own way.

In discussing various limitations commonly put on recreation, the health issue is the most important. In Appendix I information is presented to demonstrate that proper treatment of a surface water source — including coagulation, filtration, disinfection of the water — provides ample protection against any contamination attributable to recreation. Nevertheless, the public health issue more than any other has limited recreation on water supply reservoirs in the Northeastern states. This region has long relied on watershed protection as the prime safeguard of the public health and has imposed stringent restrictions on public access to reservoirs to further this end. In theory, complete watershed restriction is the best protection possible, but in practice such restrictions are inadequate to protect public health: violations inevitably occur, and contamination may be introduced onto the watershed by other mechanisms, such as the settlement of air pollutants. Although every public water system has some minimal level of treatment to supplement watershed protection, that treatment is often inadequate and unreliable. While few serious outbreaks of disease have occurred in areas served by major reservoir systems with watershed restrictions and minimum treatment, the margin of safety is small, especially today.

The essence of the restriction issue is this: safety of drinking water requires upgrading of treatment to include a full filtration procedure as well as disinfection. With adequate treatment, one of the subsidiary benefits will be increased potential for recreation.

One prominent water resource expert writes:[8]

> "Every water utility that uses a pond or reservoir for its water source and does not now filter, should be planning to do so — the sooner the better."

The worst threats to public health come from unregulated (or poorly regulated) development of the watershed; from pollutants of nearby highways; and from the settlement of air pollutants. Properly managed, recreation is a compatible activity on watersheds, and vastly preferable to most other land uses. It is the natural adjunct to high-quality treatment techniques which should be made standard.

Because the controversy about recreation on water supply reservoirs is an old one in professional circles, many questions about the practice have been raised — and answered. To summarize the case for increased use, the major questions are reviewed below. They fall into three general categories. Those related to the health issue are the most common and the most important. The second category questions, based on unfavorable emotional or aesthetic perceptions of reservoir recreation, are related to these and sometimes confused with them. The third category includes concerns based on the cost of recreation and necessary water treatment improvements.

The Health Issue

> "With all the pressures of population, and with the dangers of new pollutants in the environment, we should be looking for more restrictions on our reservoirs and watersheds, not less."

This argument labels recreation as a major source of pollution, which it is not, and equates it with such hazards as industrial effluents, the runoff from new subdivisions, and the aerial application of insecticides. As urbanization continues to intrude into watershed areas, all of these hazards can have a major deleterious effect on water quality. As with all environmental issues, perspective is important. While recreation may have a measurable effect on water quality, that effect will be insignificant if properly controlled. Within the guidelines presented in this handbook, competent treatment can easily handle the effects of recreational activities on a reservoir. Recreation must be distinguished from major pollution sources, some of whose effects cannot be controlled by most common treatment methods. We should be looking for more intensive restrictions on major pollution sources in watershed areas, but recreation is not one of them.

The most efficient way to protect watersheds from contamination is to assure compatible land uses. Recreation is far more compatible with a reservoir watershed than residential, commercial or industrial development. Therefore, it is a land use which ought to be promoted.

"Recently we have heard that chlorination is dangerous because it creates carcinogens in water. If recreation is increased, more chlorine will be used, and that will increase the danger. Therefore, we should not allow more recreation."

It has recently been discovered that some cities drawing their water from polluted rivers have trace amounts of carcinogenic chemicals in their water, and some of these have been tentatively related to chlorination. But this link to chlorination results not from the disinfection of drinking water but more probably because of disinfection of treated sewage effluent before it is dumped in rivers. Chlorination of treated sewage naturally requires a much higher dose of chlorine than does disinfection of drinking water. The large doses of chlorine may interact with organic chemicals in the sewage and in the river to produce possibly carcinogenic chemicals.

Water drawn from reservoirs is, or should be, completely free of industrial chemicals. In general, reservoir water is of higher quality than river water. As far as is presently known, the minimal amount of chlorination used to treat this clean water has not produced any carcinogenic chemicals.

Recreational activities may contribute increased turbidity and bacterial counts to reservoir water, but these effects can be treated well by filtration. Increased chlorination should not be necessary in most instances, provided adequate filtration is available.

If chlorination is found to be a sufficient hazard in general to warrant replacement by other disinfection techniques, substitutes such as ozonation are available already.

In the case of reservoir water systems, therefore, there presently appears to be no chance that the marginal increase in chlorination which might accompany increased recreation will produce dangerous chemicals. If dangerous chemicals are discovered in protected reservoirs, there may be cause to modify treatment or convert to other sources of water, but recreation plays no part in this controversy.

"Recreation activities, especially body contact sports, are a health threat. Perhaps bacterial diseases can be controlled by water treatment, but not enough is known about viruses to be sure that they can be kept out of the drinking water if recreation is allowed."

One fact that most people don't recognize is that body contact sports are, in themselves, quite harmless to the water. It is contamination of the water by human fecal wastes that must be controlled, and these are usually associated with improperly supervised land activities. Many managers who feel they are being conservative by only allowing fishing are in fact already permitting as much pollution from recreational activity as they would if they allowed swimming and boating. Adequate water treatment will remove the bacterial contamination from recreation, which is slight to start with, so that none of it reaches the consumer.

As for viruses, while they are admittedly not fully understood, it has been proven that conventional water treatment, especially chlorination, will deactivate all enteric viruses. Where recreation has been allowed on public drinking water reservoirs, the bacteriological and virological standards of the water remain just as high as where it is prohibited.

"Polluting the water up to a safe limit is completely the wrong approach in managing reservoirs. No liberties should be taken where the public health is concerned."

Permitting recreation on reservoirs does not imply "polluting up to a safe limit." This argument is largely rhetorical and based on a misleading premise. The bacteriological standards for drinking water are extremely stringent, and they are rarely exceeded in well maintained reservoir systems. Where recreation is allowed, although the reservoir water may actually be contaminated to a slight extent, the quality standards of the treatment plant are still met. Hence, the safe level of pollution which is allowed in the water distributed to consumers is not affected by the presence of recreation.

"Under controlled circumstances, recreation is probably safe, but one instance of vandalism can undo all the safeguards and pose a serious threat to public health."

To start with, recreation is not proceeding under controlled circumstances if the water quality is vulnerable to acts of vandalism against recreation facilities. If toilet facilities are properly and permanently installed (no portable units should be used), there is little a vandal can do to harm water quality. If anything, the bad habits of the general public are more of a threat to water quality than the nefarious schemes of vandals, which are generally aimed more at producing satisfying visual chaos than subtle bacteriological effects. While it is ugly, depressing and expensive, vandalism and its effects will not endanger public health and can be kept well below any danger point by careful design, supervision, and maintenance of recreation facilities.

"It is not up to the general public to decide how to manage reservoirs. Professional water managers should decide if recreation is safe because they know the most about water management."

Water managers should most definitely be consulted about instituting recreation at a reservoir site; no one should argue otherwise. However, opinions of water managers vary widely. Qualified experts have taken opposite sides of the recreation issue in the past. And it is a fact that most United States reservoirs have multiple uses, including recreation, without instances of damage to public health. In the end, the public must make the basic policy decision about recreation because it is they who pay for the water and usually own the reservoir. If the decision is made in favor of recreation, the public must cooperate with water managers and plan recreation in such a way as to allow them to achieve their professional standards.

"A lot of emphasis is placed on high quality water treatment when reservoir recreation is discussed. Why should I pay to put in an expensive treatment plant just to allow a few people to swim."

The argument raises an important point. It implies that recreation is the rationale for installing better water treatment, which is not true. Rather, recreation is a valuable side benefit accompanying the adoption of advanced treatment techniques which should be made standard for reasons of public health. Recent events, including the passage of the Federal Safe Drinking Water Act, show that the issue of water supply is receiving new attention. Though it may be some time before all communities can afford to install rapid filtration plants, many attitudes which have been built on a different perception of water quality issues should be reexamined. One of these attitudes is the presumption that recreation on reservoirs automatically implies swimming, and that the choice before the public is a dichotomy of unlimited recreation on the one hand and complete closing of the watershed on the other. While communities are waiting to improve the quality of their treatment plants, assuming that they do not have complete facilities at the moment, many sorts of recreation, short of intensive forms, could be implemented.

Emotional and Aesthetic Perceptions

"I don't like people swimming in the water I drink. I pay for the water and I have the right to prevent recreation on the reservoir."

Outside the Northeast, people accept such recreation without complaint. Recreation on reservoirs is widely allowed, not only in many parts of the United States but in many other countries too. No adverse health effects from swimming in reservoirs have been detected where the recreation is controlled and where water treatment is adequate and reliable. Furthermore, even where it is not allowed, illegal swimming in reservoirs is common, so we probably have often drunk water that somebody has been swimming in. Since people who swim illegally are not following any rules, is the situation any better than it would be if more people were allowed to swim with proper supervision and upgraded water treatment?

"Once recreation is allowed, a little will lead to a lot. The public won't be satisfied with controlled recreation and the situation will get out of hand."

This consideration can be answered with a simple "no." Many reservoirs have functioned for years with a constant, controlled, and relatively low level of recreation. Supervision is necessary to keep recreation under control, but communities which have established recreation at their reservoirs are generally pleased with the results.

"If recreation is allowed, more water treatment will have to be installed and the water will wind up tasting or smelling bad. Unprocessed water is the best and healthiest; I don't want my water to be full of chlorine."

With added filtration, reservoir water may actually taste better, as the algae and organic matter would be removed. High chlorine doses are not usually necessary in reservoir water. The most highly chlorinated water is usually that from rivers or other highly polluted primary sources which must be very thoroughly treated. This argument also erroneously assumes that recreation is the reason for putting in better water treatment. Its worst assumption is that unprocessed water is the best and the safest. History has emphatically proved that presumption to be false.

"Recreation will attract a lot of undesirable people to the area. Land values will go down and all sorts of tacky commercial development will take place."

To take the argument point by point, one can start by asking who are the undesirable people. If the concern reflects simple prejudice against certain types of people, the problem is not one of water supply. If the concern is about possible rowdy behavior on the part of certain groups, it ought to be seriously considered in planning for increased use. Recreation areas can quite easily be designed to encourage quiet and unobjectionable types of recreation. As for land values, experience shows that land adjacent to parks and similar recreation facilities tends to increase in value rather than the reverse. Regulating tacky commercial development is the job of land use planning, which is a large subject in itself. Local governments should have mechanisms to control such development.

"There are plenty of opportunities for recreation elsewhere; people should make more of the facilities they have and leave reservoirs alone."

Reservoirs offer a quality of recreation which is disappearing rapidly elsewhere. The costs of duplicating the quality of the environment around reservoirs just for purposes of recreation would be prohibitively expensive, so it makes sense to make the best use of resources which exist at reservoirs. Watershed management standards are high and serve to prevent the degradation of the landscape by recreation. If adequate money or personnel cannot be provided to maintain standards and have recreation too, then recreation must be reduced or curtailed. By developing more recreation at reservoirs, crowding can be cut down at other facilities, and new opportunities opened up. It is rare that recreation potential elsewhere in an area is so great as to make it pointless to develop reservoirs.

"I like some kinds of recreation, such as swimming and hiking, but I hate powerboating and snowmobiles. I would rather have no recreation allowed at all than have to put up with a lot of activities I don't like."

Finding compatible activities for a particular site is one of the most important parts of recreation planning. The mix of activities must be decided on by community agreement. With good planning, no one should be particularly dissatisfied with the result. It is the highest intensity recreational uses which tend to offend the most people, usually those requiring the use of gasoline engines. These activities are among the last to be considered for implementation at reservoir sites.

"The reservoirs are beautiful as they are. I'd rather keep them untouched than to see them ruined by recreation."

Many reservoir areas are beautiful. There are few places around cities where environments of their quality still exist. However, pressures of population growth are forcing cities to examine how they can make the most of their present resources, and reservoir areas represent valuable land for open space development. Developing recreation does not mean that the area will be ruined. If it is felt that some natural characteristics of an area are unique, those portions of the site should support only low levels of recreation access which do almost nothing to alter the semiwilderness character of the land. In the national wilderness areas, lands are subjected to recreational use without damage.

The Cost of Recreation

> "Recreation will just raise the cost of water to consumers because more treatment will have to be installed and the facilities will cost a lot to install and maintain."

This question has two parts: who should pay for treatment and who should pay for recreation. As has been repeated throughout this handbook, full water treatment should be made standard at every reservoir because new environmental standards require it, not so that recreation can increase. Hence, the first part of the answer is that the treatment level of the water source should be examined on its own merits. The efficiency of treatment in dealing with contamination ascribed to recreation is often less significant than its efficiency in dealing with the raw water. If a filtration plant is already in place, then the contamination associated with recreation can easily be handled by the plant. No additional treatment is needed, though the reliability of the treatment ought to be carefully monitored. If full treatment is not available, it probably should be installed in any case, an expense properly borne by consumers.

The expense of the recreation facilities should not be borne by those who pay for the water unless they agree to it. It may happen that the primary beneficiaries of recreation facilities will be the local water users. In that case, the small costs of low intensity recreation facilities may appropriately be borne by them. Otherwise, the cost of recreation should be borne by the users of the recreation facilities or by the local government. Reservoir recreation areas represent a bargain to the community because the expense of developing them can be far less than creating another recreation site of comparable quality.

> "There isn't enough demand to justify the cost of establishing recreation. Not enough people would use the facilities if they were built."

Demand is difficult to predict. Absence of public pressure to build a facility does not imply that demand does not exist. In areas where the public is accustomed to restricted reservoirs, they may be unaware of the recreational possibilities of those sites. Furthermore, demand for a facility generally increases over time as the public becomes aware of its existence. In addition, opportunities for recreation ought to be made available, as a matter of principle, to those who have few other recreational opportunities. Reservoir recreation areas can offer a quality of recreation to low income groups and to the elderly that they cannot obtain otherwise. In speaking about demand, it is important to emphasize that recreation facilities can be minimal to start with and can be expanded if demand and available funding warrant.

> "Even if the costs of recreation are not borne by the water users directly, taxes will have to go up to support the facility."

There are many different ways to pay the costs of recreational facilities; increasing taxes is only one way. User charges and government grants are other ways. However, assuming that costs will be paid through taxes, is that a bad way of financing recreation? If a majority of citizens in a town vote to have recreation, then bearing the expense through town taxes is one appropriate way to pay for it. If tax increases are unpalatable to a majority of voters, other methods of financing can be used. Reservoir areas offer very high quality recreation at lower costs than at other available sites.

> "Setting up a user charge discriminates against poor people, who cannot afford to pay. They won't be able to use the site even if it is developed."

Various special programs have been set up in the past to get around inequities of this sort. One option is to have no user charge on certain days, so that those who cannot afford to pay can at least have some opportunities to use the facility. Another way might be to let all children in free under the auspicies of local schools. User charges could take the form of parking charges, under the assumption that people who have the money to own a car can pay a small user fee and that people coming by other means of transportation can get in free. While ultimately the costs these people impose on the site for maintenance and the like will have to be carried by others, this may not be an inequitable arrangement. Frequently similar financing arrangements are used to pay for schools, libraries, public parks and other public facilities.

"Allowing recreation exposes the water company to law suits if accidents occur."

This question also has two parts: who will be exposed to the costs of accidents, and what are the accidents involved. A recreation site can be operated by the public parks department, a public water company, a private water company or a concessionaire. Each has different means of insuring against the costs of accidents. Public agencies are often insured through the state itself. A private water company could lease land to a public agency for recreation and then state-operated insurance could be available. Many states regulate leases by private water companies, and particular regulations should be examined before proposing this alternative. Private operations as well as public ones can obtain broad insurance coverage. The cost of this insurance should be included in the cost of recreation. Since local parks must have coverage against the liabilities of accidents, guidelines could be obtained from a local park agency.

A second part of the question is more complicated. Recreation will increase the chance of bodily injuries, and the types of insurance described above are designed to cover those types of accidents. However, water managers are responsible for the quality of water supplies, and in many states are personally criminally liable if they knowingly permit contamination or inadequate treatment. As long as this liability exists, water supply managers must be given authority in managing reservoir recreation. Laws of each state and locality should be analyzed to determine the extent of this liability stemming from various recreation activities.

2
Reservoir Recreation in Six Northeastern States

This chapter provides background information on conditions in six states: Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island. These six states were chosen for special attention because of their large population of 47 million, and because they generally have not permitted recreational use of their water supply reservoirs.

For each state there is a discussion of how the issue of reservoir recreation presently stands. A map is provided showing the state's reservoirs, whether open or closed to recreation, and centers of population in Standard Metropolitan Statistical Areas.

At the end of this handbook there is an appendix containing supplementary references to the discussions in this chapter. In each case, the first part of each state's section quotes laws and regulations in that state which relate to reservoir recreation. The other supplements are not uniform in content, since the issue has developed differently in different places. Where possible, a listing of reservoirs is given which shows the degree of recreation allowed at each, and the level of treatment available.

The information here is only a guide. Actual conditions at a reservoir may have changed since the data on which this book is based were compiled. Readers can determine actual conditions at local sites by contacting the operator of the reservoir or actually visiting the site.

Connecticut

Connecticut is one of the more conservative states on the issue of reservoir recreation. The State Department of Health still opposes body contact recreation on drinking water reservoirs. Without the support of this Department, there is little chance that Section 25-43 of the State Code, which prohibits swimming in reservoirs, will be amended or revoked.

In recent years, two acts have been passed which affect watershed activities. P.A. 73-225, approved in June 1973, treats recreation directly. It allows water managers to permit fishing and other recreation (after consultation with the commissioner of the health department), but it reserves to the Department of Health the right to prohibit recreation if water treatment facilities are deemed inadequate. Significantly, the act allows the Department of Health to specify the degree of treatment required for any new reservoir constructed after January 1, 1975 if recreation is to be allowed. The Act also calls for the use of permits for fishing.

The second act (P.A. 74-303) amends the Department of Health regulations to give the Department authority over the sale of watershed lands. While this does not directly involve recreation, it shows the Department's concern over the influence of urbanization on reservoir water quality.

In January 1973, Connecticut published "A Plan of Conservation and Development for Connecticut: Policies for Land and Water Resources."[1] The plan is only an advisory proposal, but its recommendations are important. The plan is based on extensive evaluation of the state's water resources. On watersheds used for the production of drinking water, areas of strictly limited development were designated. The Department of Health hopes that regulations similar to those in P.A. 74-303 can be extended eventually to regulate development in all these areas.

The Conservation and Development Plan includes several recommendations which affect future recreation policies:

Policy No. 2

"Provide a wide variety of high quality outdoor recreational opportunities to all citizens with highest priority given to the purchase and development of facilities in and near the state's urban areas."

"2a. In the purchase and development of recreation areas, give top priority to sites within and close to major population centers.

2e. Take advantage of every opportunity to increase the amount of shoreline land available to the public for recreational use.

2i. Under certain conditions, swimming should be allowed in storage reservoirs, but not in terminal reservoirs."

The Conservation and Development Plan may represent a new departure for the state, but its recommendation that bathing be permitted in reservoirs runs counter to existing law. Unless the Department of Health changes its traditional stance on the issue that recommendation is unlikely to be implemented. On the other hand, the plan coincides with the Department's objectives to control urbanization on watersheds.[2] In addition, the Department has sanctioned fishing and other recreation under proper conditions (P.A. 73-522). Since reservoirs typically are located near population centers, the plan confers high priority on their use for recreation. These considerations may lead to comprehensive recreation planning for water supply watershed areas. Major Connecticut reservoirs are shown in Figure 2.

Hartford, the State's Capitol, has a severe shortage of water-based recreation opportunities. It also has an extensive system of reservoirs, among them the Barkhamstead Reservoir, the largest drinking water reservoir in the State. Hartford's Metropolitan District Commission, which operates the city's water system, is firmly opposed to any recreational use of its watersheds, and has closed them off completely. The MDC justified its position in a paper by Alexander J. Minkus, entitled, "Recreational Use of Reservoirs," published in the March 1966 edition of the *Journal of the American Water Works Association.* Briefly, this article recounts the MDC's bad experience with recreation at its Compensating Reservoir, which is not used for water supply. The MDC's attitude toward recreation, which is considerably more conservative than that of the Department of Health, has limited recreation for a substantial fraction of the state's population.

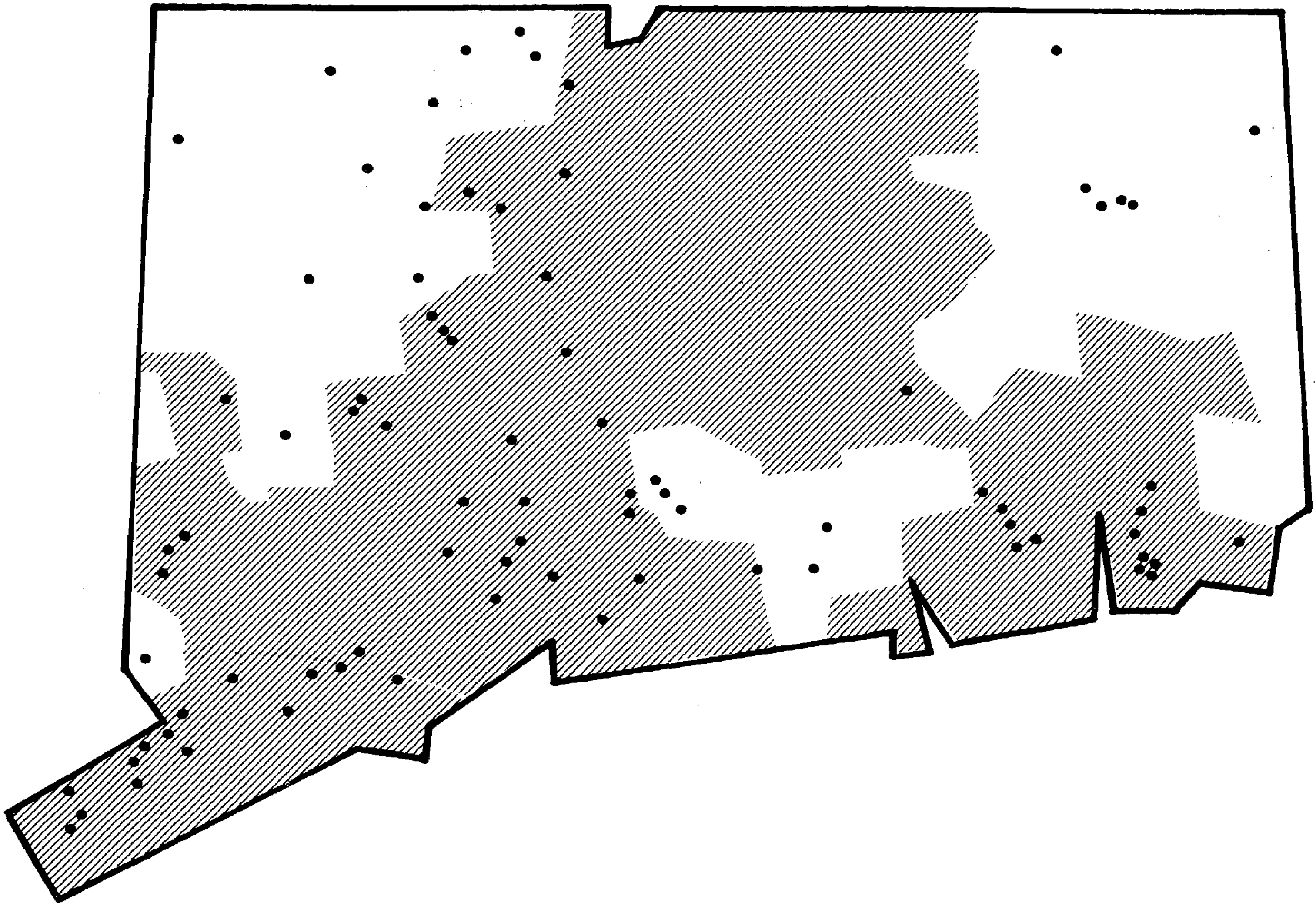


Figure 2
Connecticut Reserviors in Relation to Standard
Metropolitan Statistical Areas (SMSAs)

Connecticut

Standard Metropolitan Statistical Areas
• Reservoir Areas

40

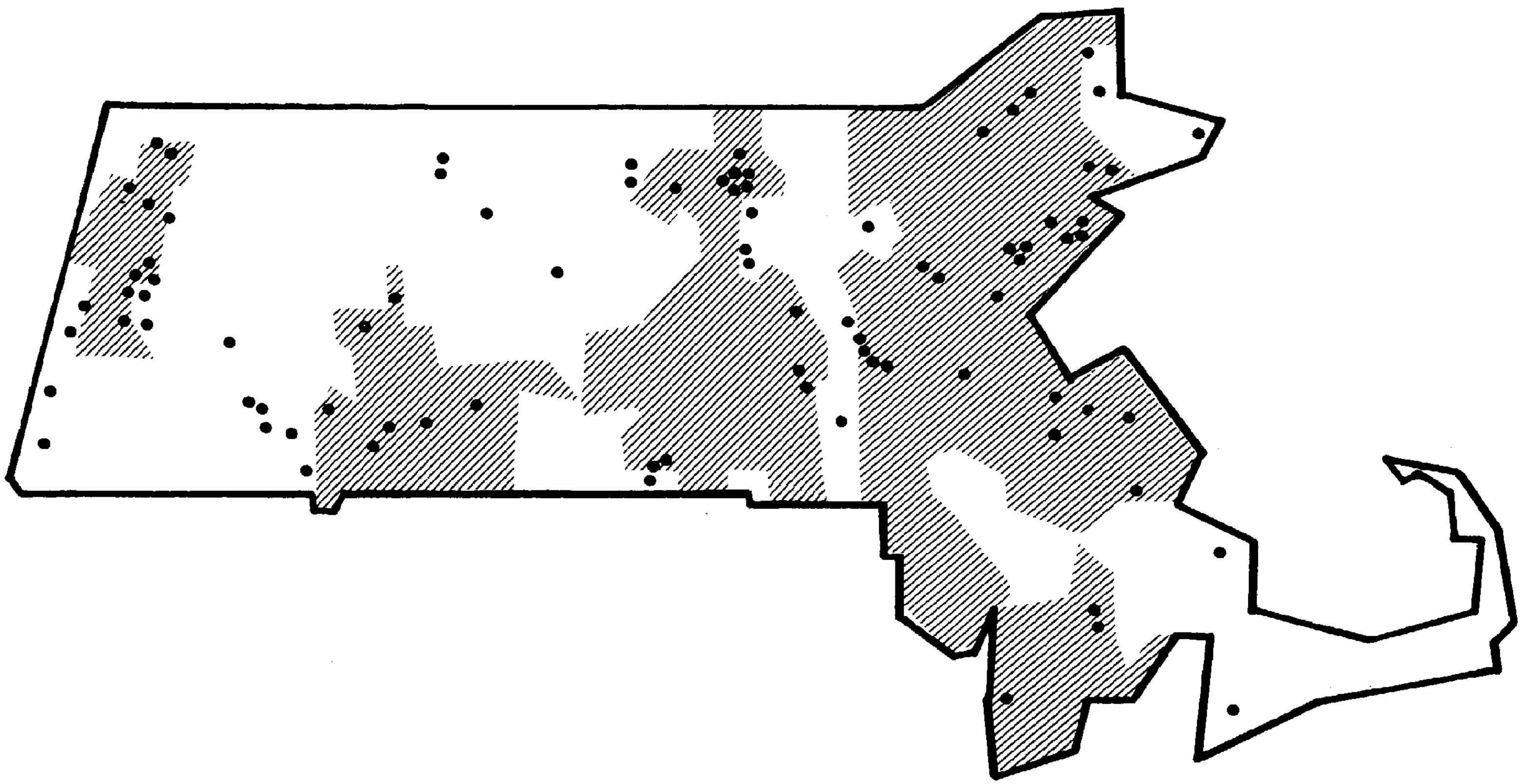


Figure 3
Massachusetts Reservoirs in Relation to SMSAs

Massachusetts

Standard Metropolitan Statistical Areas
• Reservoir Areas

Massachusetts

Massachusetts was one of the first states to develop reservoirs for public water supply and continues traditions of reservoir management from the days when water treatment did not adequately control water-borne diseases. The Department of Public Health is still highly skeptical of plans to open reservoirs to increased recreation, though it realizes that recreation is being carried out successfully in many other states.

Since 1884, bathing in reservoirs has been prohibited by law, and exceptions are possible only by a special act of the State Legislature. In addition, Section 160 of Chapter 111 of the State Code gives the Department of Public Health authority to prohibit swimming in reservoirs and sets a high fine for violators. Unless both the law and the public health department regulations are repealed, planners should concentrate on opening restricted properties for activities other than swimming.

Major Massachusetts reservoirs are shown in Figure 3.

Boston's water and the water of many communities in eastern Massachusetts is provided by the Metropolitan District Commission, which was created in 1895. The MDC originally used the Wachusetts Reservoir and Aqueduct for its supply, but by the mid-twenties a shortage of water required the construction of the Quabbin Reservoir, which is still one of the largest man-made reservoirs in the world built expressly for drinking water (see Case Study, Quabbin Reservoir).

Very limited recreation is permitted on the MDC reservoirs. Fishing from boats and shore fishing are permitted at Quabbin. Hiking, bird watching and picnicking are allowed in certain areas. At Wachusetts, recreation is restricted to shore fishing only. In the Rutland area and near the shore of Wachusetts Reservoir, MDC watershed lands are open for snowmobiling. Pamphlets and brochures, available from the Boston Headquarters of the MDC, illustrate the recreational facilities available at their reservoir sites.

The MDC is proud of the quality of its water even though it is not filtered:

"Top Quality Water Needs No Purification Facilities"

> Purification facilities required by most water supplies are not needed for the Metropolitan Water District, thanks to the system's high quality water and drastic restrictions on recreational use and public access to reservoirs. Treatment is confined to small amounts of chlorine and ammonia as water enters distribution pipes."

This lack of filtration does indeed limit the amount of recreation appropriate on most of the MDC's reservoirs, but on the two largest — Quabbin and Wachusetts — far more recreation could be permitted than is presently allowed.

Of interest to recreation planners is a letter of the Attorney General's office reprinted as Appendix 2.2. The Department of Public Health requested clarification of the water manager's legal liability for water supply contamination stemming from authorized recreation. The letter was circulated by the Department of Public Health to all water managers in the State. It concludes that criminal penalties may accrue to water supply officials who, through misfeasance, permit recreational activities which contaminate the water supply. This letter is a serious impediment to those who are interested in expanding the recreational use of reservoirs. Not only is it typical of Massachusetts' strongly entrenched conservative attitude toward reservoir recreation, it serves to reinforce and perpetuate it.

No separate listing of Massachusetts reservoirs is supplied here, as the most complete available list is now twenty years out of date. If readers wish to refer to the complete list, it is available as Senate No. 665, *Special Report of the Department of Public Health Relative to the Preservation of the Purity of Certain Water Supplies within the Commonwealth*, 1954, pp. 66-75.

New Jersey

New Jersey presently has 55 drinking water reservoirs, most of which serve the densely populated northern area. These are shown in Figure 4. The southern portion of the state is served mainly by groundwater from the large and dependable aquifers of the coastal plains region.

The total area of New Jersey's reservoirs is over 16,000 acres, and recreation is permitted on about 40% of that area. Of the area open for recreation, however, 56% is contained in two state-owned reservoirs, the Spruce Run (1,275 acres) and the Round Valley (2,350 acres, currently the State's largest). Recently the City of Newark has opened the reservoirs of the Pequannock Watershed to recreation, and these comprise another 31% of the reservoir area open to recreation (2,015 acres). The remaining 13% is divided as follows: 472 acres on public owned reservoirs, and 309 acres on privately owned reservoirs.

New Jersey has changed its official outlook on reservoir recreation. The relevant state laws are presented in Appendix 3.1 and a table showing the level of recreation permitted in major New Jersey reservoirs is contained in Appendix 3.2. After the successful development of recreation at the two State reservoirs and Newark's Pequannock watershed, more reservoirs may well be opened to public use.

The two State reservoirs impound the waters of the South Branch of the Raritan River. They were created under the long-range water conservation and development program authorized by the 1958 Water Supply Law and companion Water Bond Act. Under this authority, the Department of Environmental Protection, through its Division of Water Resources, is charged with the development, construction and operation (on a self-sustaining and self-liquidating basis) of these storage reservoir facilities. Spruce Run provides a maximum sustained drinking water yield of 11 billion gallons per year, and Round Valley provides 55 billion gallons per year.

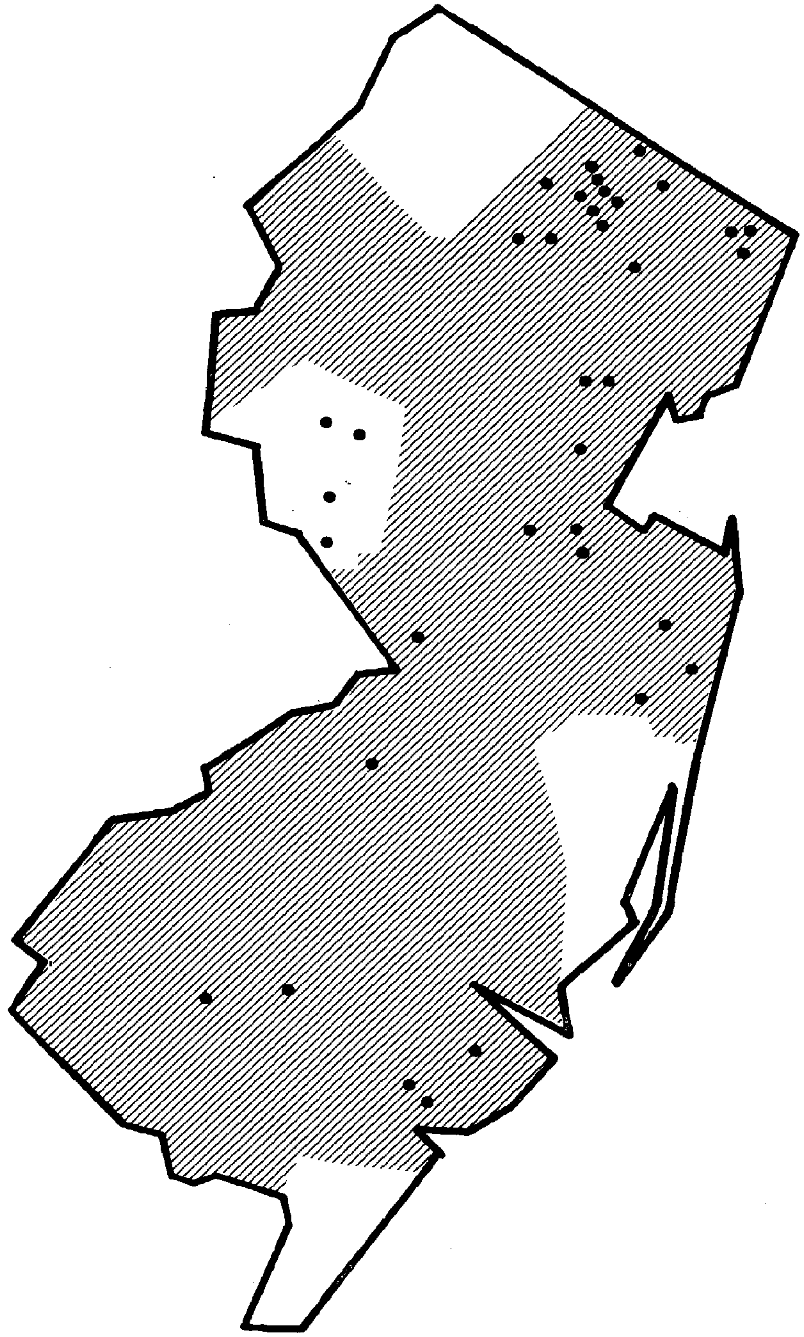
Recreation opportunities at both reservoirs are very liberal compared to practice prevailing in the rest of New Jersey. Camping, swimming, hunting, fishing, ice fishing, and ice boating are permitted. Campers must hike in; swimmers must use designated areas; boats are limited to 10 horsepower motors; and fishing, hunting, trapping, and field trails are permitted in designated areas. Pets must be leashed, except for hunting dogs at field trails. Scuba diving and snowmobiling are prohibited at this time. Strangely Round Valley does not yet permit picnicking or ball playing.

Fees are assessed for various activities. Spruce Run charges a $1 parking fee for cars and $5 for buses. Parking at Round Valley is free. The camping fee is $3 per night at Spruce Run, $3.50 at Round Valley. A $.25 entrance fee is also assessed at Round Valley for people over 12 and under 65.

Seven more sites have been acquired for the development of State reservoirs, though construction dates have not been set. The sites will be developed in the Longwood Valley Reservoir in the Rockaway section; the Washington Valley Reservoir in the Whippany section of the Passaic River Valley; the Confluence Reservoir in the north and south branches; the Six Mile Run Reservoir in the Millstone section of the Raritan River Basin; the Tocks Island Reservoir in the Delaware section; the Hackettstown Reservoir in the Musconetcong Section of the Delaware River Basin; and the Manasquan Reservoir in the Manasquan section of the Atlantic Slope Streams. Together these ultimately will provide over 28,000 acres of water surface open for public recreation under Title 58, Chapter 21 of the New Jersey State Code. The largest portion of this area will belong to the Tocks Island Dam Project, where a controversial multi-purpose reservoir has been proposed for water supply, flood control, hydro-electric power, and recreation.

State officials hope that local water companies will follow the State's lead and open more of their holdings to public recreation. There are over 9,000 acres of reservoirs closed to the public, and most of them lie in the heavily populated northern half of the State. These smaller water bodies could provide convenient, accessible recreation to a large number of people.

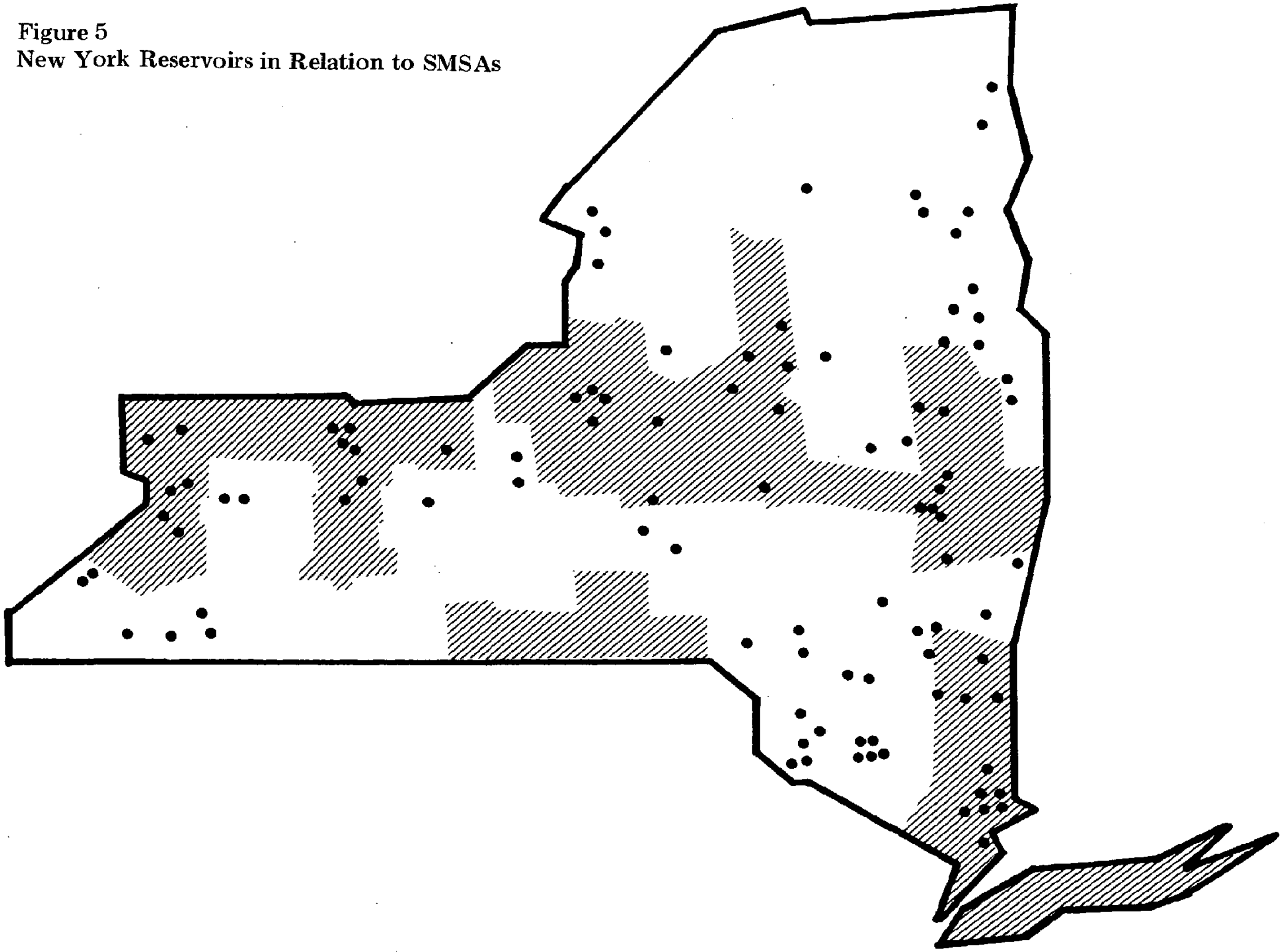
Figure 4
New Jersey Reservoirs in Relation to SMSAs



New Jersey

Standard Metropolitan Statistical Areas
Reservoir Areas

Figure 5
New York Reservoirs in Relation to SMSAs



New York

Standard Metropolitan Statistical Areas
Reservoir Areas

New York

A map of the major water supply reservoirs in New York is presented in Figure 5. While the Department of Health has left to the cities and towns the prerogative of establishing, within broad limits, their own regulations for their water supplies, the Department has published a statement of policy on recreational uses, reproduced here:

Public Water Supply Policy

Recreational Use
of Public Water
Supply Reservoirs

Situation

A Recreational use of water resources is expected to substantially increase in view of population growth, standards of living and increasing leisure time.

B Water supply has generally taken precedence over all other uses of reservoirs throughout the State because of the fundamental need for an ample, potable water supply to satisfy public and industrial consumption requirements. Public water supply reservoirs, restricted to this single use, exist in many areas of New York State.

C Many future reservoirs will reflect multiple uses, one of which will be public water supply.

D Water supply reservoirs are attractive for recreational uses.

E Recreational use of public water supply reservoirs may be economically desirable.

F Sanitary methodology is available for safeguarding water quality in the reservoirs and on the watershed.

Department Policy

1 The New York State Department of Health, therefore, does not oppose recreational use of multi-purpose reservoirs serving also as public water supply sources, provided:

A **Watershed Control** (Total Drainage Basin)

(1) regulations are developed, adopted and enforced to insure effective watershed control by a utility, agency or cooperating agencies of jurisdiction.

(2) sanitary design practices and operational procedures are satisfied to assure acceptable treatment and disposal of human, animal, industrial, commercial and agricultural wastes. This includes waste disposal from watercraft.

(3) effective sanitary and safety patrol is maintained on the watershed.

(4) use of all or any part of the watershed is restricted under conditions of low watershed yield, drought or other adverse situations inimical to public water supply needs, which are preeminent.

(5) application of chemicals on the watershed to control insects, vegetation, small animals, etc., are effectively regulated. This includes control of aquatic fauna and flora.

B **Public Water Supply**

(1) intakes, wells and other points of direct inflow into public water supplies are protected so as to preclude contamination from human and other wastes, toxic substances and pesticides with regard to topography, water depth, prevailing winds and currents and rate of water withdrawal.

(2) acceptable processing including chemical coagulation, sedimentation, filtration and disinfection, or equivalent sanitary preparation, is installed and operative, when technologically indicated, to produce potable water meeting established drinking water standards.

2 The New York State Department of Health recommends maintenance of single-purpose use for public water supply reservoirs when nearby suitable lakes, multi-purpose impoundments, rivers and streams exist for convenient recreation.

New York State Department of Health
Hollis S. Ingraham, M.D.
Commissioner

Division of Sanitary Engineering
Bureau of Public Water Supply — '73

Water managers in New York State have traditionally been conservative in their attitude toward reservoir recreation. In the light of the above policy statement, however, there is opportunity for a change in policy on a case by case basis. Restrictions which have been imposed on the local level can be removed at the local level. Appendix 4.1 presents the relevant New York State Laws.

New York City is an exception to the general rule. It has the power to restrict recreation on reservoirs at a great distance from its consumers. Its system is very large and currently has no filtration capability. A general change in policy is unlikely at this time. The names and capacities of New York City's reservoirs are given in Appendix 4.2

A complete inventory of water systems in the State of New York has been compiled by the Bureau of Public Water Supply, under the New York State Department of Health. Unfortunately, while it describes every town's source in great detail, it does not distinguish reservoirs from rivers, but refers only to "surface sources." Readers, if they know that a certain town gets its water from a reservoir, can easily find out all the pertinent technical information about that reservoir by consulting this inventory. Appendix 4.3 presents the restrictions on recreation at many of the water supply reservoirs in New York State.

Pennsylvania

Although Pennsylvania was the first state with a major public water supply, it did not develop reservoir systems until later than Massachusetts and New York. Some of these reservoirs are shown in Figure 6. Philadelphia still uses the Schuylkill River for much of its water a century and a half after the creation of the Philadelphia Water Works. Other major Pennsylvania cities also use river water instead of reservoirs. Harrisburg, the State Capitol, draws water from the Susquehanna.

Experience with treating lower quality river water evidently has made the state health department more amenable than others in the Northeast to allowing body contact recreation in reservoirs. Full water treatment is common in most systems.

Chlorination (or other disinfection) of all supplies is required by law, but reservoirs may not be used for recreation (fishing, boating, swimming) unless filtration is also supplied. It is now the intention of the Department of Natural Resources to encourage multiple use of reservoirs. While few reservoirs have been opened for swimming, many are open for boating, fishing, and other recreation activities.

In order to upgrade the quality of municipal water supplies, the state has launched a program to train water treatment plant operators. The Certification Act, signed in January 1969, requires that each public water supply have a minimum of two certified operators. It is hoped that both operations and maintenance will be measurably improved, particularly at the smaller systems which are characteristically the most susceptible to operational breakdowns and substandard levels of disinfection.

At the state level, multiple use of reservoir facilities is encouraged. The legal basis for this policy is presented in Appendix 5.1. Aside from swimming, Pennsylvania reservoirs do tend to have slightly more recreation than other states in the Northeast region, but more than 60% remain closed. Appendix 5.2 shows the recreation permitted at major Pennsylvania reservoirs.

A recent study[1] of the subject showed that 36% of the water agencies sampled permit some degree of recreational activities on their reservoirs. Of those permitting recreation, more than one-half allow fishing from the shore, hunting and hiking. Low intensity uses of watershed lands for such activities as nature study and picnicking were widely permitted, and riding, camping, trapping, and skiing were also listed, though less frequently. Waterskiing and powerboating were the activities least approved by operating agencies, followed closely by swimming and sailing.

In May 1967, the Pennsylvania general assembly implemented a $500 million Conservation and Reclamation Bond Program, providing financing for broad actions by state and local government in the areas of parks, recreation, conservation and reclamation. The program extends ten years, to July 1, 1977. Through the Department of Community Affairs, $75 million is authorized for state grants-in-aid to municipalities to pay up to 50% of the cost of

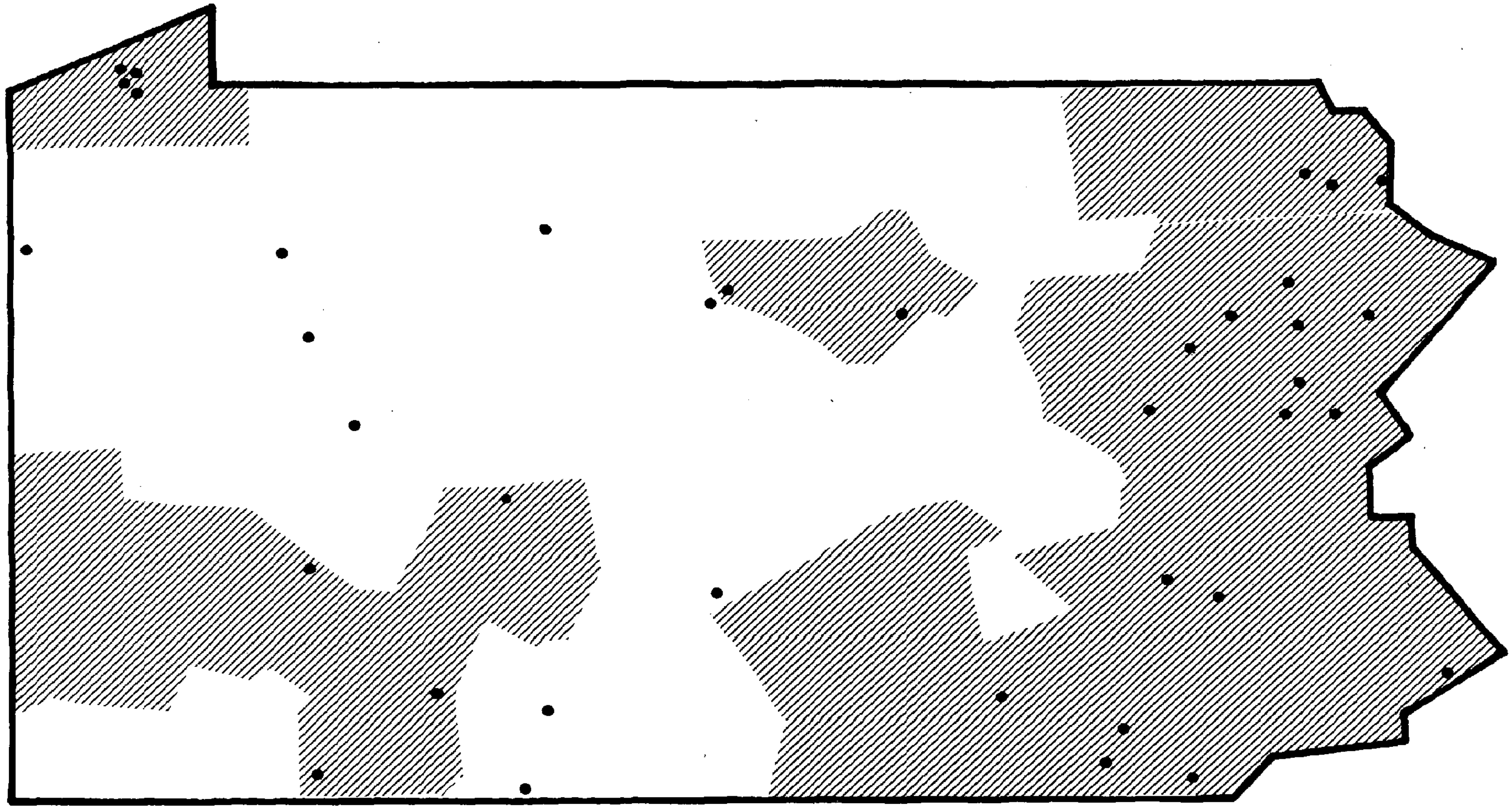
1. **acquisition** of municipal park, recreation, and open space lands.
2. **development** of municipal park and recreation lands for outdoor recreation.
3. **studies** conducted to determine park and recreation needs.

If a municipality is eligible for federal aid, the state adjusts its aid such that the municipality pays a minimum of 20% of the cost of the project. Leased land is eligible under the project. The only restriction is that the life of the lease be commensurate with the life of the facility to be developed, and the lease must be approved by the Department of Community Affairs.

Those interested in creating a new facility and who wish grant aid should send a letter of intent to the DCA regional recreation specialist at the appropriate DCA regional office. The letter should contain

1. A narrative project description
2. Description of neighborhood or community served
3. Municipal map showing project location
4. Cost estimates.

A preliminary study of community recreational needs is encouraged by DCA, and it may require one in some circumstances. The proper form for an application for such a study is contained in 16 Pa. Code Chapter 5, paragraphs 28 and 29.



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Pennsylvania

Standard Metropolitan Statistical Areas
• Reservoir Areas

Figure 6
Pennsylvania Reservoirs in Relation to SMSAs

Rhode Island

Section 46-14-1 of the laws of Rhode Island prohibits body contact with drinking water supplies. While this is the only reference to reservoir recreation in the State's laws (Appendix 6.1, Rhode Island has been especially conservative in its policies toward reservoir recreation and prohibits almost all use of its reservoirs for public recreation. Figure 7 shows the major Rhode Island reservoirs. Scituate Reservoir, the largest in the state, is completely closed to recreation. There is no access comparable to that granted the public at the large reservoirs in neighboring Massachusetts.

Rhode Island has a very long coastline for its size, but the shore most available to the population of Providence is listed by the State Department of Health as polluted and unfit for bathing. This has led to greater pressure for some public access to the State's reservoirs and caused the Providence *Journal* to reverse its editorial stand against the recreational use of reservoirs which dated to 1960.[1]

In 1967, Philip Holton, the Chief Engineer for the City of Providence, called for the opening of Scituate's tributary reservoirs. His statement was precipitated by the policy statement of the American Water Works Association as published in 1959. Under this policy, however, terminal reservoirs are not to be developed for recreation. Despite its size, the city classifies Scituate itself as a terminal reservoir.

At the moment, recreation on water supplies is severely limited. Despite Philip Holton's recommendations, recreation is not permitted on Providence's reservoirs. Shore fishing is permitted by the Cities of Providence and Woonsocket at their reservoirs, but no boats are allowed and the number of fishermen is limited.

The debate still continues. The State Department of Health remains firmly opposed to recreation on water supplies. The Statewide Planning Board now represents those who want reservoirs opened to some degree of recreation. Rhode Island's high population density will continue to be a compelling reason to provide recreation opportunities on reservoirs. Gradual change in this direction may be expected.

Like many major cities in the Northeast, Providence does not filter its drinking water. This remains a major impediment to any extensive development of recreation on its reservoirs. Limited recreation on the Scituate Reservoir is advocated by the Statewide Planning Board. It also recommends that recreation be planned from the start for the proposed Big River Reservoir, which will lie to the south of Scituate. The major Rhode Island reservoirs are listed in Appendix 6.2, along with reservoir ownership and water treatment at each.

Rhode Island

Standard Metropolitan Statistical Areas
• Reservoir Areas

Figure 7
Rhode Island Reservoirs in Relation to SMSAs

3
Planning Increased Recreation

This chapter of the handbook provides the information required to develop a sound recreation plan. First the types of possible activities and the requisite site facilities are discussed. Then the question of the number and types of users who could be expected at the facility is examined. In the context of facilities and demand, the economics of developing and operating the site are analyzed, and possible financing schemes are presented. The fourth section introduces some of the legal, social and institutional constraints which may influence the best level of recreational use. Finally, the steps in preparing a successful plan are summarized. The planning information is integrated with the economic and political factors to assess the best level of recreational usage for a wide variety of reservoir types.

Reservoirs will always be special recreation sites, and in the interest of public welfare should always be carefully managed. Planning for multiple use of these reservoirs should involve recreation officials and water managers, as well as concerned members of the public. Cooperation between all interested parties is necessary to produce the best plan.

Recreation Facility Planning

The various forms of recreation require different types of facilities and planning. This section surveys potential recreation activities and discusses the suitability of each in a reservoir recreation development. Water-based, land-based and winter activities are discussed separately. For each type of activity, the most significant problems with its inclusion in a reservoir site are described. A sound plan must consider the compatibility of activities selected for inclusion. Care has been taken to note potential conflicts between activities, and ways to resolve or reduce them. The section concludes with a description of support facilities which may be necessary for various types of recreation development.

Water Based Activities

Swimming Swimming is a desirable activity wherever it is practical. Some 70% of all outdoor recreation is water-oriented, and swimming is the favorite water-based recreation.

On very large reservoirs, swimming is possible, without deterioration of the finished water quality, if simple chlorination is provided as a safeguard. On other reservoirs, however, it is recommended that swimming not be permitted unless all the water produced by the reservoir ultimately receives both filtration and chlorination. This is a conservative approach and may necessitate treatment plant construction if swimming is desired.

Most terminal reservoirs can sustain body contact sports without undue risk, but management problems may be difficult. In a terminal reservoir, a factor of safety has to be included to allow for the absence of substantial residence time. Allowing water to stand for 30 days is generally presumed to be adequate to eliminate bacteria and viruses through natural processes. In all but the largest terminal reservoirs, that residence time cannot be guaranteed. Therefore, treatment must be sufficient to protect against the worst case situation, in which a "slug" of pollution could travel in concentrated form directly to the intake. Not only must the plant be capable of filtration and chlorination, but it must be fully reliable during the summer season. Although this level of treatment is common when the raw water is of relatively low quality, such as that from a river, it is not common on high-quality reservoirs.

At smaller reservoirs, where the safety radius around the water intake may be accessible to swimmers, there should be constant supervision of the safety radius.

Where swimming opportunities elsewhere are very limited, it may well be worth the cost to develop a terminal reservoir for swimming. However, in systems involving a hierarchy of reservoirs, of which the last small terminal reservoir is a part, there may be better opportunities for swimming in collection reservoirs where the minimum residence time would be assured and no safety radius around an intake would be necessary.

Site Location and Size It is important to locate the swimming area in such a way as to ensure maximum dilution of the water before it reaches the intake. This consideration is less important in a collection reservoir, providing the terminal reservoir to which the water is transferred has full treatment capability, but should be observed wherever possible. Not only should a radius be set around the intake within which swimming should not be allowed, but the beaches should be located away from the line of flow between major inlets and the water intake. Eddies might be set up which could carry an undiluted slug of pollution directly to a treatment plant, where it might temporarily overwhelm the disinfection capability.

The design of the bathing facility is dictated by the reservoir geography, the expected demand, and the funds available for construction, supervision, and maintenance. Even fluctuation of reservoir water levels must be taken into account. Beaches should be surfaced to the minimum water height and sometimes swimming piers must be built to float on the water as they often are at ocean marinas to accommodate the tides.

Since reservoir swimming areas may be of all sizes, the best way to estimate the capacity of a particular site is on the basis of area per person, rather than numbers per linear foot of waterline. Figure 8 presents guidelines for calculating beach and water capacity for swimming. Figures 9 and 10 illustrate typical beach layouts.

Many people coming to swim may

Figure 8
Beach Capacity Guidelines

Type of Area	Water	Beach	Backup and Buffer	Total	
High Density	30	45	400	475	Square Feet Needed Per Person
Medium Density	40	60	800	900	
Low Density	60	90	1200	1350	

Source: George Fogg, *Park Planning Guidelines* (National Recreation and Parks Association: Arlington, Va., 1974).

want to picnic as well. Picnic sites should be accessible from the swimming site without obstruction by support facilities, such as parking lots. (Picnicking is discussed under "Land Based Activities" below.) Reservoir swimming areas should never allow food on the beach itself, and should be prominently marked to this effect.

Safety The beach area must, of course, be located in a safe place for swimming. The swimming area must be free of underwater hazards, such as rock outcroppings, submerged trees, and all litter and refuse. A lifeguard should be provided for each visually unobstructed stretch of beach, but there should be a minimum of one every 400 feet.

If the shore slope is steep, piers should be built. Safety floats should be provided in the water no further than 150 feet from the shore. If possible, swimming floats should be positioned at the outer limits of the swimming area.

The lifeguard building should be located with a clear view of the water, and must have access to the road for the use of emergency vehicles. Telephone service must be provided.

No boating should be allowed within the supervised swimming area. The water should be cordoned off by floating lines and buoys where necessary to identify the area under the lifeguard's supervision. Swimming outside the area should be prohibited.

Sanitary Facilities The number and type of sanitary facilities may be specified in relevant state health codes. Otherwise, the tables contained in "Support Facilities" below serve as a guide.

Fishing Fishing is a very popular sport; each year about one out of every three Americans participates in fishing. Reservoir managers have been under quite heavy pressure from organized sportsmen to permit fishing, and this pressure has resulted in some ill feeling toward fishermen on the part of water managers. As we have recounted, the activity of fishing in itself is harmless to reservoir water quality. It is the sanitary habits of fishermen, and to a much lesser extent fish cleaning, which are of concern. One would presume that fishermen would be responsible caretakers of the outdoors, but this is frequently a false presumption.

Management of fishing may be more difficult at a small local reservoir than at a larger distant one. Because of the convenience, those with only a casual interest in fishing may be attracted to the site. They often are ignorant of amenities and uninterested in policing each other. The larger and more distant sites will tend to attract a more dedicated enthusiast, who may exhibit more responsible behavior.

Regulation Fishing can be accomplished either from the shore or from a boat. Opinions differ about which is safer from a health point of view. Patrols along the shores of reservoirs in which fishing is allowed have found human feces close to the water's edge, and it seems to matter little if only fishing from boats is allowed. It is easy to land on shore surreptitiously and patrols cannot prevent this.

Some reservoirs have fishing zones along the shore and restricted water areas near the intake where boats are not allowed. This makes sense in a terminal reservoir, but on a collection reservoir there need be no such limitations.

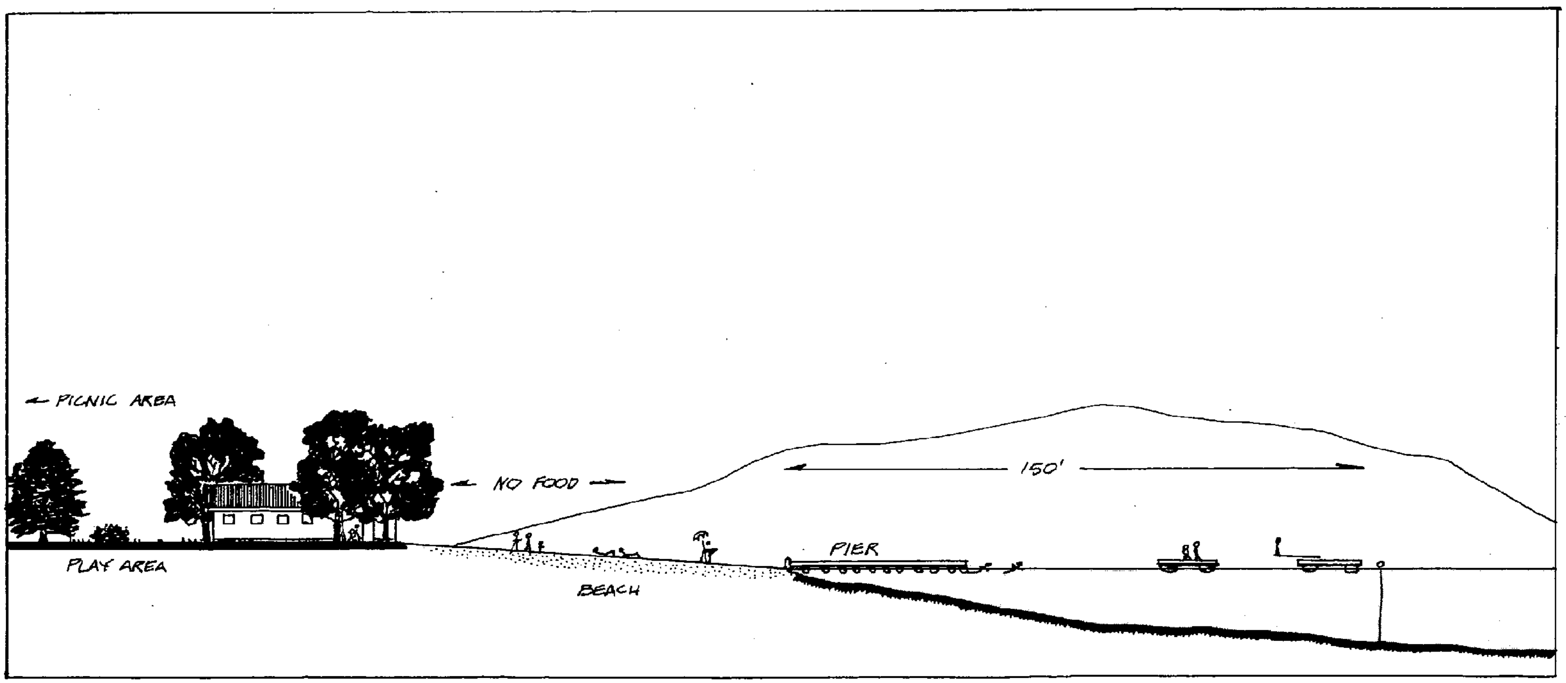
Land access can be controlled by posting parts of the shoreline against fishing. Restricted water zones can be marked by floating buoys or barrels, on a cable suspended at the water level.

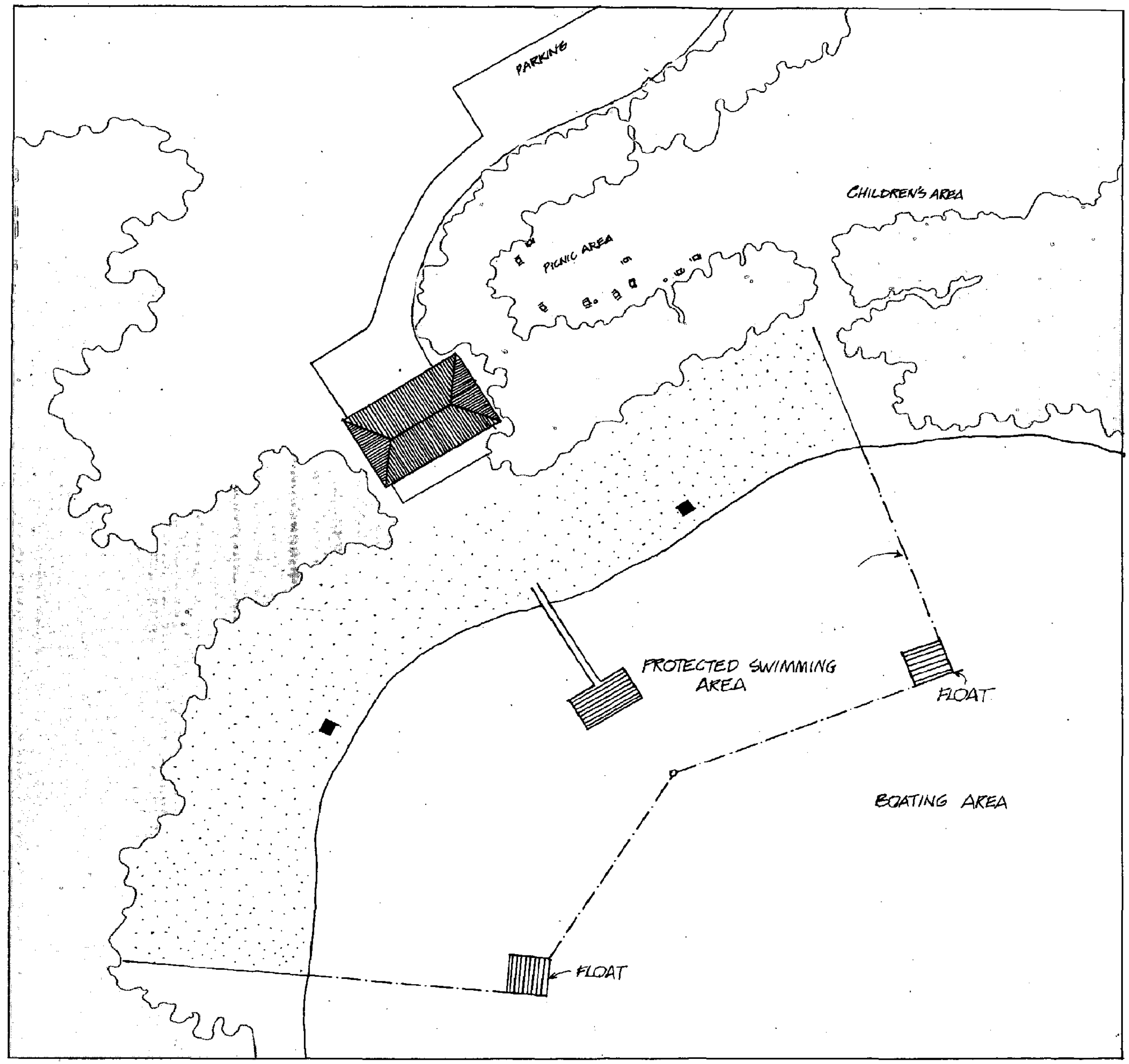
Regulation of the number of fishermen coming to the reservoir can be accomplished in two ways. The easiest way is to require the use of rental boats, and allow no shore fishing. This insures some income to the area to cover maintenance costs. Another way is to permit private boats, but have limited access to boat ramps and have a daily ceiling on the total number of boats allowed. In a remote site, this ceiling would be the size of the parking lot.

Some regulation of shore fishing is possible as well. In remote areas where people cannot easily walk to the site, numbers can be limited by access to parking lots. Another way is to allow fishing only by special permits which can be obtained through a town of-

Figure 10
Reservoir Beach Layout (Plan)

Figure 9
Reservoir Beach Layout (Section)




PARKING
CHILDREN'S AREA
PICNIC AREA
PROTECTED SWIMMING AREA
FLOAT
BOATING AREA
FLOAT

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fice, or to allow only local residents to fish.

For large or popular sites, a brochure should be prepared to inform fishermen of the regulations. The brochure should contain a brief statement of all regulations applicable to the site. A map of the site showing all shore and water fishing zones and access points should be included. Restricted areas should be clearly marked on the map as well as on the land and water. *Figure 11 depicts the type of information* which should be provided. The brochure should emphasize that the reservoir is used for drinking water and must be protected.

Sanitary Facilities Toilet facilities should be provided at the boat launching ramp and at all parking lots providing access. Guidelines for the number and type are contained in "Support Facilities," below.

Boating Some form of boating is possible at almost any reservoir but, as with swimming, the main problem with boating is management and control. Sources of pollution from boats include human wastes and petroleum compounds. To permit boating, regulations and water treatment must be able to control both.

Boating should not be allowed on terminal reservoirs unless filtration is provided, and even then no motors should be allowed. On small terminal reservoirs, management difficulties may be too great to permit boating even if filtration is provided, particularly if large numbers of people use the site.

Boating is possible on any collection reservoir. If water is ultimately filtered or if the reservoir is large, then motors may be permitted.

Boating can be divided into three classes:

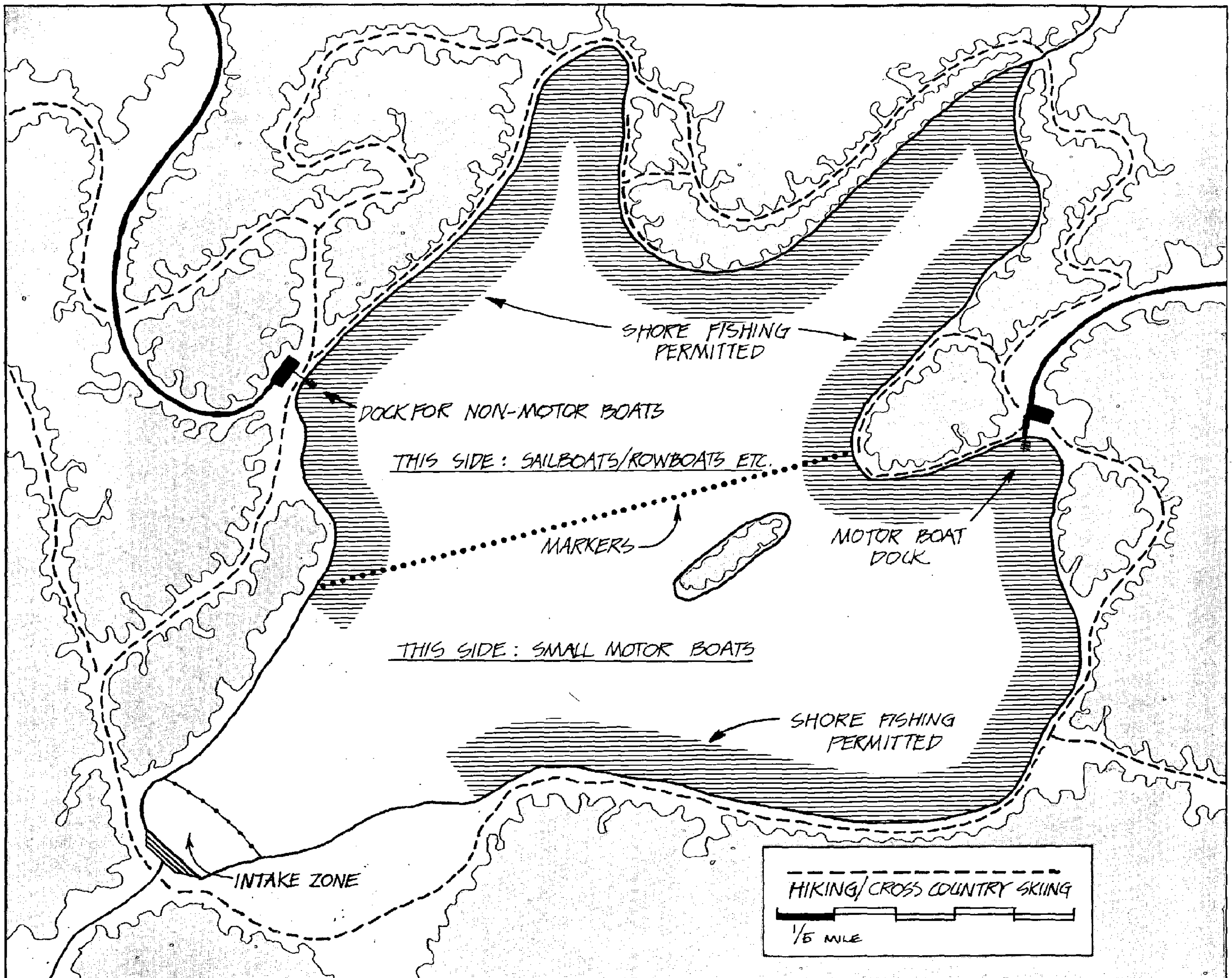
non-motorized boating (canoes, rowboats, sailboats) for fishing or sightseeing, rental or private;
motorized boating for fishing, with power limitation;
motorized pleasure boating, no power limitation.

The use of rented boats with no motors would be appropriate on a small reservoir where the total number of boats would have to be kept under control. On small terminal reservoirs sailboats might not be rented unless swimming were also permitted, since mishaps are common.

On larger reservoirs, there is no reason to limit sailboats for fear of surreptitious or accidental swimming. Provided swimming is formally restricted, violations would be very infrequent and inconsequential. Restricting boating to non-motorized boats may be desirable even on larger reservoirs to maintain the quiet and calm of the environment and to prevent oil and gasoline from contaminating the water and creating taste and odor problems. Assuming that gasoline and oil contamination are not a problem, then the decision must be based on the compatibility of other recreational activities with motorboating.

Small boats with low horsepower engines (about 10 hp maximum) are of practical use for fishing, and do not come under the category of pleasure boats. To allow high-powered pleasure boats requires a commitment to patrol the reservoir, for there will be considerable pressure for body-contact sports and waterskiing will be a favored activity. Motorboat zones should be established if fast craft are allowed so that fishing, swimming and other activities can be safely pursued. If the area is large enough, separation can be satisfactorily achieved. If not, compatibility might be achieved by allowing powerboats only on certain days. There is logic in the argument that the semi-wilderness quality of reservoirs makes them particularly suited for quiet, solitary enjoyment, and that large motorboats have ample opportunities elsewhere. Motor recreation does impose a burden on those who object to it.

Figure 11
General Plan:
Fishing Zones, Boating Zones,
Hiking and Cross Country Trails


SHORE FISHING
PERMITTED
DOCK FOR NON-MOTOR BOATS
THIS SIDE : SAILBOATS/ROWBOATS ETC.
MARKERS
MOTOR BOAT
DOCK
THIS SIDE : SMALL MOTOR BOATS
SHORE FISHING
PERMITTED
INTAKE ZONE
HIKING/CROSS COUNTRY SKIING
1/5 MILE

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The number of boats of each type permitted to use the site depends on the surface area of the reservoir. Figure 12 presents some density limits for common types of boating. If zones are employed to ensure compatibility of uses, these density limits should be applied separately to the area of each zone.

Regulations The following regulations should be observed in any case:

a. Prohibit vessels with any form of portable toilet capable of being emptied into the reservoir. In most cases, the health department may request that all boats with any form of toilet or sink be excluded from the reservoir.

b. Open the reservoir to boating only during those periods when the operating agency can maintain adequate patrol.

c. Maintain a responsible person on duty at all times at launching ramps when the ramps are in operation to inspect all boats being launched to ensure compliance with applicable regulations. For example, if only fishing is permitted, other pleasure boating can be controlled by requiring a valid fishing license for entry.

d. Provide fail-safe features at all fuel loading facilities to prevent the spillage of fuel into the reservoir waters and prohibit the storage of fuel in containers over the water.

Boat Launching Ramps Although mechanical boat launching devices exist, the most common form of launch is from a ramp extending into the water. The ramp should have a slope of about 13-15%, and no less than 7%. The ramp may be quite wide to permit multiple launchings, but each launching lane must be at least 12 feet wide. Figure 13 shows a typical plan for a boating facility.

Docks Docks will have to be built for rental boats kept permanently at the site during the boating season. These could be wooden or metal. They should be designed to permit disassembly or removal from the water during winter to protect them against ice damage. In addition, courtesy docks, usually one for every two launching lanes, should be provided for those who launch their own boats.

Parking One parking space should be available for every rental boat provided. In addition, parking for privately-owned cars and boat trailers should be provided at a rate of something more than one for every private boat. Boating parties arriving with their own boat may be used as a guideline. Multiply the expected number of private boats by 1.5 and add the number of rental boats to arrive at parking lot size.

The details of parking lot design are presented in "Support Facilities."

Adjacent Land Activities

Recreational activities planned on the land adjacent to reservoirs fall into two rough categories: low intensity and high intensity. Low intensity activities usually involve unstructured recreation, such as hiking or picnicking. These require minimal facilities and place little if any stress on the

Figure 12

Recommended Density Limits for Boating

Type of Boating	Maximum Number of Boats Per Acre of Reservoir Water
High Speed/Motorboats Unrestricted Engine Size	.33
Low Speed Motorboats ≤10HP.	1
Non-Motorized Boats (No Sail)	2
Fishing (trolling)	1 .5
Sailboats	1

Source: Urban Systems Research & Engineering, Inc.

reservoir environment. High intensity activities require expensive facilities, special supervision, or both, They may tend to place significant stress on the reservoir environment. An example would be a golf course, with its use of fertilizers and pesticides.

Low Intensity Activities

The activities with the least effect on the reservoir are informal relaxation, sightseeing, nature-study, strolling, and so on. These can be permitted at any reservoir because, if necessary, they can be set up away from the water. The water itself may be fenced off from public access if the treatment level is low.

The facilities for unstructured informal recreation are the same as those found in most city parks. Lawns for lounging and quiet play activities should be provided, paths for hiking through nearby woods may be built, and children's playground equipment can be provided.

There is abundant literature on the layouts of lawns and playgrounds (the Bibliography includes several such sources), and since these areas will be used on a daily basis their construction at reservoir recreation areas is fundamentally no different than it is anywhere else. Figure 14 illustrates a typical layout. Care must be taken of course in the landscape design that runoff from recreational areas into the reservoir is avoided.

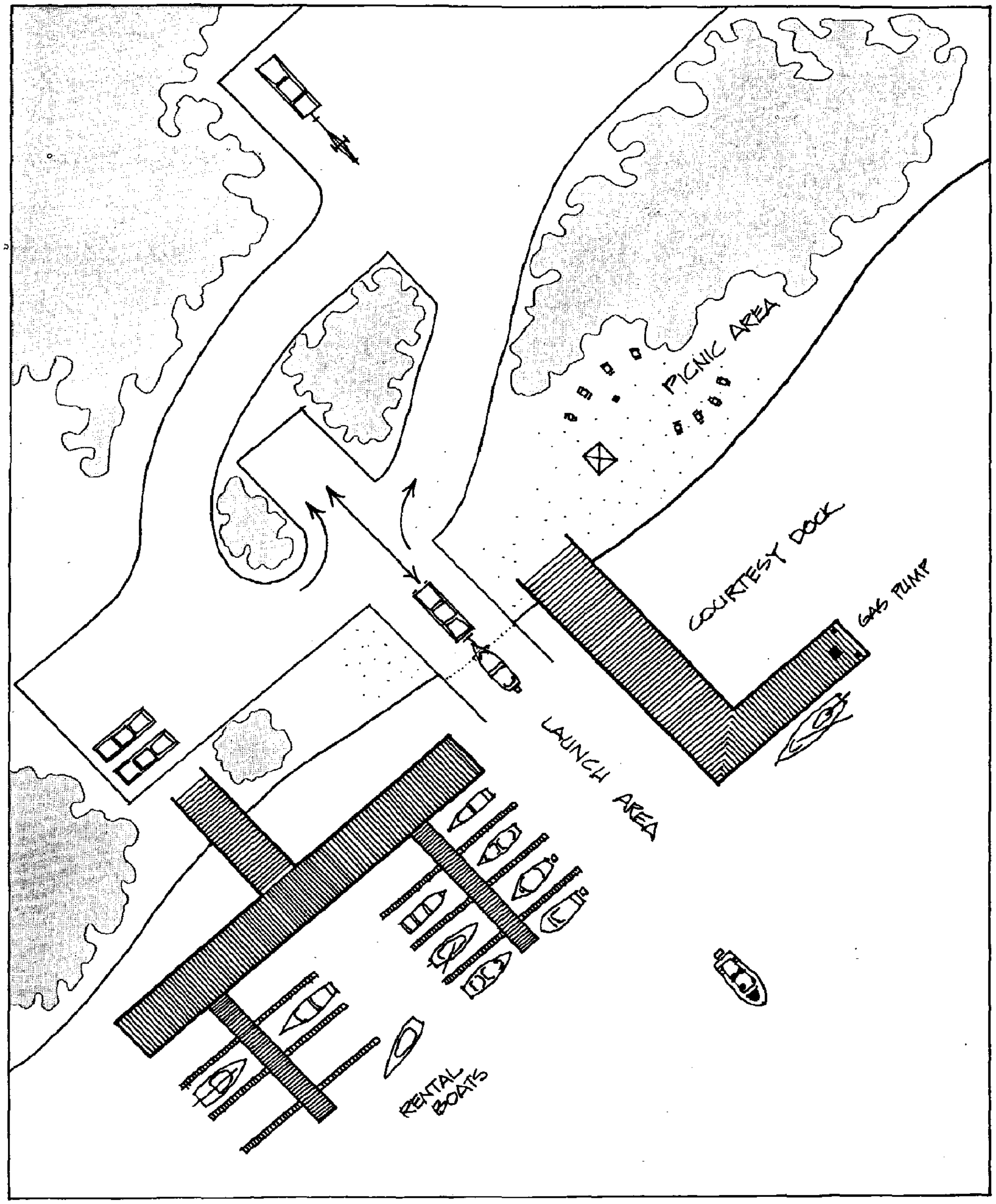


Figure 13
Plan of Boating Facilities

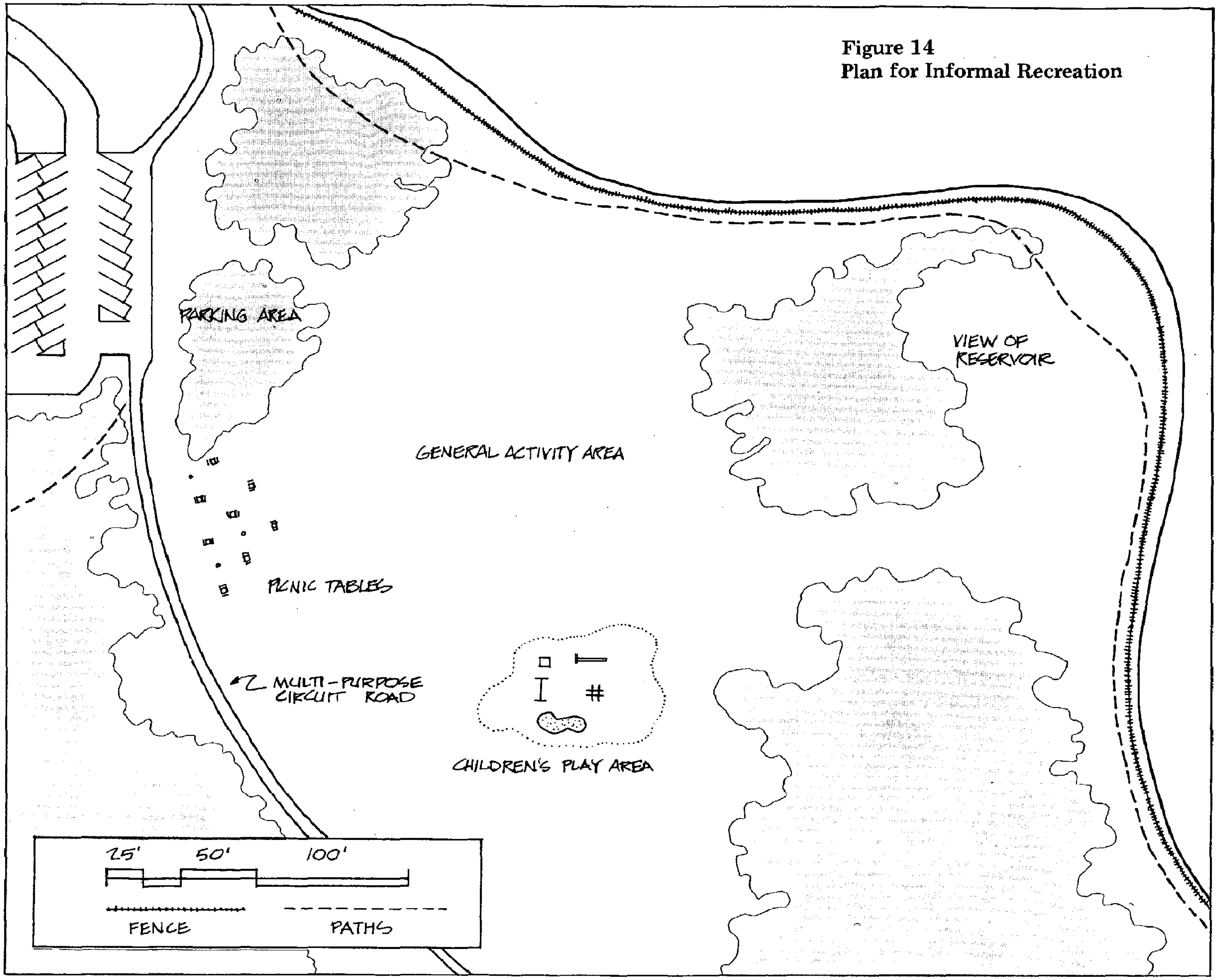


Figure 14
Plan for Informal Recreation

Hiking The layout of hiking trails must be more carefully tailored to the requirements of the reservoir. For planning purposes at reservoirs, the term hiking implies day hiking only. Overnight hikes come under the category of camping, and planning for that is taken up under *High Intensity Uses.* Day hiking trails can be no longer than about 14 miles at maximum, and all trails must loop back to the original starting point or to another park entrance. The trails should be cut inconspicuously, and at no greater grade than the material will stand without erosion. They should be planned for a variety of experiences and vistas, and if the area is to remain open in the winter, it would be wise to design them such that cross country skiers can also use them. Trails should be marked as to their length, so that hikers will not become stranded on them after dark. A possible arrangement of hiking trails is illustrated in Figure 11.

Picnicking Picnicking appeals to all ages and groups, but is particularly popular among urbanites. Picnicking is mainly ancillary to other activities. People come to a park specifically to swim, fish or boat, but also bring a picnic.

It is preferable from a maintenance point of view to develop a few large picnic areas rather than many small ones. At a major recreation area, the minimum number of tables should be 90 to 120, but on some small sites any number smaller than this would be reasonable if there were only one picnic area. There is nothing wrong with having no tables and permitting picnicking on the grass, but in wooded areas, picking up litter is expensive, and some of it may reach the water.

Tables should be separated by a minimum of ten feet, and they should not be closer than ten feet to a path — thirty feet to a major trail. About ten to fifteen picnic sites per acre is average. Each site should contain one table and bench combination (cost, about $50), but fireplaces should not be provided unless supervision is adequate. One charcoal burner type fireplace for every two to four tables is recommended.

Indispensible to any picnic area is an adequate number of good refuse bins. These should be durable, waterproof, and rodentproof, with a sturdy base to prevent animals (e.g., dogs) from overturning them. For ease of maintenance, none should be farther than 150 feet from the circulation road. Covers should be provided, and they should be properly maintained. Figure 14 shows a plan of these considerations.

Bicycling Bicycling requires the installation of bikeways with asphalt or similar smooth surfaces. On very small reservoirs, such as terminal reservoirs, a circuit path around the waterline may be a sensible investment, since it can be used for strolling, running, and maintenance vehicle access, as well as bicycling. (See the Fresh Pond Case Study.) At large recreation areas, full scale separate bicycle paths may be built which provide long and interesting routes and beautiful views of the scenery. There is considerable literature available on the proper layout of bikeways.

Team Sports Team sports come under the category of low intensity uses, even though they require some special facilities. Baseball diamonds, football and soccer fields, and other playing fields may be laid out on land near reservoirs, provided that runoff is controlled. The installation of large bleachers or a stadium should not be contemplated. Unless a high degree of planning and supervision is possible facilities should be used by casual players only, not for spectator games.

While providing facilities for game sports is compatible with reservoir management, it may be considered an inappropriate use of a reservoir environment. These sites lend themselves better to less structured activities related to the appreciation of the outdoors.

Hunting Hunting is a seasonal activity, so that although certain types of hunting are incompatible with all other activities for safety reasons, it may be considered an appropriate use of the land during the few weeks each year that it is permitted. For the purpose of planning, deer hunting should be distinguished from bird and small game hunting. Because short range shot is used, safety zones for the latter can be quite small (¼-½ mile). For deer hunting, if allowed, all other recreational access to the land should be temporarily curtailed within a mile of the area reserved for hunters. (If only shotguns are allowed, that separation may be reduced to one half mile.)

In general, the land holdings around a reservoir must include a minimum of about 400 acres.[1] The most suitable sites for hunting, then, are around large upland storage reservoirs. On smaller sites alternatives to hunting may accommodate hunting demand. These include skeet, trap, rifle, and archery ranges, as well as hunting dog training and field trial events.

With hunting opportunities elsewhere growing constantly more limited, such uses of reservoir land ought to be seriously considered, despite the negative image hunting has acquired in many places. This issue must be decided by the local community involved.

High Intensity Activities

Camping Camping traditionally has not been allowed in reservoir lands because of the problems of pollution and of fire. With people staying on the land overnight, fecal contamination of the water has been considered inevitable. And with the prospect of unsupervised campfires burning on the water shed, water managers have almost unanimously felt that permitting camping is a risk not worth taking.

There is merit to these arguments, but there may be instances in which camping is suitable on watershed lands. There are instances where lakes used for water supply, such as Sebago, have supported unrestricted recreation — including camping — for many years without a problem. By providing certain minimal facilities such as stone fireplaces and vault or pit privies in suitable locations, camping can be accommodated, as it is at New Jersey's state-run reservoirs.

The number of campers permitted into a site can be regulated, and their whereabouts known. By allowing in only backpacking campers, use of the area for camping would not be so intense as at conventional campsites where trailers and motorized camping vehicles are used.

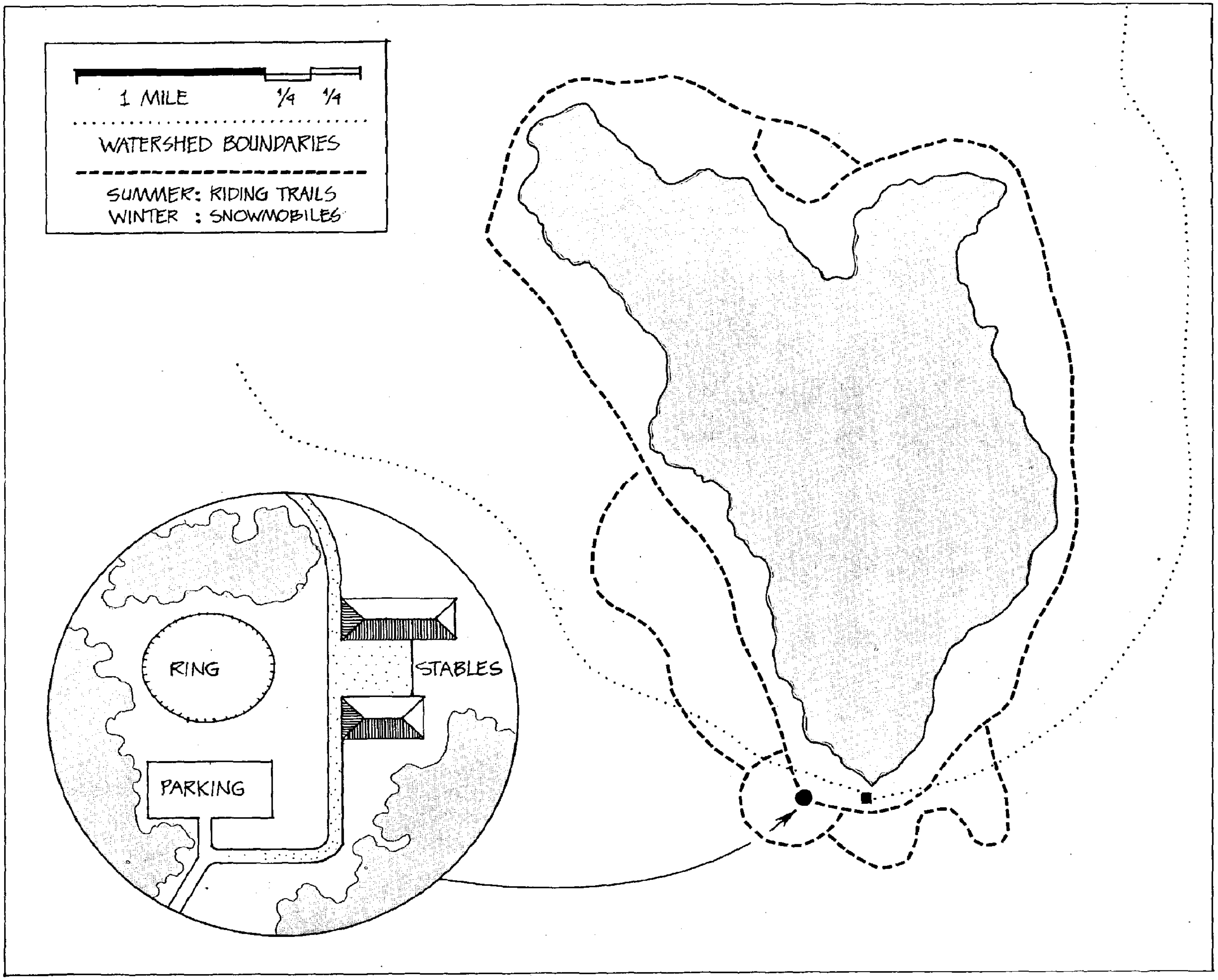
Golf Courses Golf courses, while expensive, are enjoyed by many people and can be a valuable addition at some reservoir sites. (See the Fresh Pond Case Study) They vary in size from small driving ranges which require only ten acres of land to full scale eighteen hole golf courses which should be about 170 acres in size to be challenging. Detailed information about design is available from professional landscape architects who design golf courses.

If a course is built adjacent to a reservoir, it must be fitted with a complete drainage system leading to the city storm sewer network. Runoff from the course will contain fertilizers and pesticides which can seriously degrade reservoir water quality. Such a drainage system naturally adds considerably to the expense of the course.

Support facilities for a golf course must also include a clubhouse. While a clubhouse does not have to be large or even heated, since the golfing season does not last year-round, it is an additional expense. Fortunately, the costs of maintaining the course and defraying capital expenses can be readily recouped by user charges and club membership fees.

Equestrian Activities Riding may be popular enough in a local area to support the expense of building and maintaining equestrian facilities. These will probably be more desirable near larger upstream collection reservoirs, where extensive bridle trails can be routed through undeveloped land. Although the same trails cannot be used for hiking and riding because of the manure deposited on them, riding trails may function in the winter as snowmobiling trails or cross country ski routes. The layout in Figure 15 provides a sample trail plan.

Figure 15
Layout of Equestrian Facilities


1 MILE
1/4
1/4
WATERSHED BOUNDARIES
SUMMER: RIDING TRAILS
WINTER : SNOWMOBILES
RING
STABLES
PARKING

The following regulations for a minimum program are suggested:

a. The location and operating plans for all corrals, stables, staging areas and trails must be approved by the local health department before construction;

b. Before an area is open to equestrian use, a suitable ordinance or regulation acceptable to the local health department must be established to control the horse-related activities on the watershed;

c. The operator of the recreation area should prepare a program of fencing, posting, and patrol to restrict the horses away from the reservoir water;

d. The planned program for maintenance of stables and corrals should include the following:

1. daily collection of manure and transportation off the watershed; and
2. provision of adequate drainage to direct all storm water away from stables and corrals;

e. The operator of the equestrian facilities should provide the public with copies of all applicable ordinances in a brochure which prominently indicates that the reservoir is a source of domestic water supply and must be protected;

f. Locate all trails over 100 feet from the reservoir high water level (horizontal distance);

g. Locate all stables and corrals at least 1000 feet (horizontal distance) from the maximum high water level of the reservoir and preferably off the watershed; and

h. Prohibit horses from entering the reservoir water or any tributary stream within 200 feet of reservoir shoreline.

Vacation Housing Vacation housing is sometimes suggested as a possible use for reservoir land, as sale of lots would contribute to defraying the cost of the water system. While distinctions may validly be made between housing directly adjacent to the water and housing set on watershed lands at some distance from the reservoir, (see the Case Study of the Pequannock Watershed) there are several reasons why housing is inappropriate on the watershed of a public drinking water supply.

For housing directly adjacent to or very near the water itself, the public health issue is a determining one. Although some lakes used for public water supply do have private housing along their banks, such housing usually predates the lake's use as a public water supply. The risk of contamination of the water from improperly functioning sewerage facilities is too great to permit the introduction of shoreline housing where it does not currently exist.

While the risk of contamination of the water from development at some distance from the reservoir is certainly less than the risk of housing on the shore, there is still a danger of contamination through accidents to sewer systems. Furthermore, other contaminants such as deicing salts, fertilizers, and chemicals are associated with the construction and maintenance of housing. These pose potentially greater health hazards to the population over the long term than do bacteriological contaminants, because treatment facilities are not usually equipped to deal with them. Although there already is housing development within the watersheds of many reservoirs, it seems a needless risk and an inappropriate use of the land to allow it to increase.

Winter Sports

Winter sports are becoming increasingly popular. The scope of popular winter activities has expanded beyond the perennial favorites — downhill skiing and ice skating — to include cross country skiing, snowmobiling, and other activities which were almost unrecognized by the general public ten years ago. Because these newer forms of winter recreation do not require extensive facilities such as skilifts or well-maintained ice, they can be easily and cheaply established at reservoir sites.

Water managers fear that fecal contamination from recreationists out on the snow will wash down into the reservoir with the spring floods and cause significant contamination of the water. While there is no doubt that this kind of contamination can occur, it can be well controlled by careful planning, simple precautions and the provision of certain basic sanitary facilities. Because of the difficulty of patroling open land in the winter, it has always been easy for recreationists to trespass on reservoir lands during this season. The advent of the snowmobile has greatly compounded this problem. The development of controlled winter recreation may often be the most prudent option available to reservoir managers.

In the Northeastern states, reservoirs are usually frozen over from mid-December to mid-March. The ice is rough and covered with snow, so that winter recreation is basically land-bound. Planning for winter recreation can be treated largely as a problem of maximizing compatible land uses.

Whether to allow access to the ice at all must be decided on a case by case basis. Both water quality and public safety must be considered. If access to the water is permitted in the summer, walking on the ice in winter will pose no special health problem. Safety is another matter: the ice must be thick enough to carry weight. Smaller reservoirs (i.e., most terminal reservoirs) seldom have safe ice because of the constant flow of water into the distribution system and the flucuation of the water level. Even when some areas have safe ice, the region near the intake is usually treacherously thin. Rescue equipment, including a ladder, rope, and float, should be provided at convenient stations along the shore if any traffic on the ice is to be permitted.

Informal Land-Based Winter Recreation In the winter landscape, informal unstructured recreation can take on a variety of forms. Tobogganing, sledding and sliding down hills on other devices are always popular. In light snow cover people enjoy walking, bird watching and other simple outdoor activities. Children get particular enjoyment from these winter pastimes. Walking on the ice should be prohibited unless it is known to be at least four inches thick. The intake area should be cordoned off.

Cross Country Skiing Cross country skiing has recently become popular. It provides pleasant, exhilarating exercise, the equipment is cheap compared with downhill ski equipment, and crowded, expensive ski resorts are unnecessary for participation. Reservoir sites can provide beautiful and varied terrain perfectly suited to cross country skiing.

The trails laid out for summer hiking can double as cross country trails. Markers, of course, should be affixed to trees well above the snow level. The trails should be wide enough for two abreast — about 6 feet. Level stopping points should be provided where there are attractive views. A plan for trails is presented in Figure 11.

The trails can be laid out to begin and end at the central parking lots. Lengths and difficulties of trails can be marked much as downhill ski trails are marked, using an illustrated map of the reservoir area as a background. Skiers can thus plan the length of time their outing will take.

A waist-high platform for waxing skis is a useful addition near the parking lot. At the least, a small level area for waxing and donning equipment should be opened next to the beginning of trails.

Snowshoeing Snowshoeing is not nearly as popular as cross country skiing, but interest in it is increasing. Virtually the only requirement for snowshoeing is legal access to reservoir lands, as the sport requires few if any trails unless the woods are very dense. The radius of activity of snowshoers around a parking lot or other access point will be smaller than that of cross country skiers, making the activity easy to regulate. Protected reservoir lands are ideal for the sport, and it is well worth promoting.

Skating In the more northern states, large lakes and reservoirs may not lend themselves to ice skating. During freezing the ice surface often becomes bumpy from the action of winds, the snow removal from the ice is difficult.

Two forms of skating should be considered — on the ice itself if the surface is acceptable and safe, and on semi-artificial rinks on the shore. To form rinks, a small stream may be impounded or a natural bowl in the earth may be flooded with water from the reservoir. The ice thus produced will be a higher quality for skating than that on the reservoir and can be groomed by repeated flooding. Rinks are safer than deepwater ice too, since they are shallow and often frozen solid. No matter what ice is used for skating, it must be at least four inches thick.

Traditionally, warming fires are built around skating ice, and benches are provided nearby for resting and changing of skates. There is no reason why fires cannot be provided near rinks on the shore provided they are built in fireplaces and supervision is available while they are lit. The risk of forest fire is very low in the winter.

It is highly recommended, especially if use of a skating facility is high, that winterized toilet facilities be provided.

Ice Fishing In some parts of the country where this sport is popular, elaborate ice fishing shelters are used which contain such comforts as heating, television and electric lights, portable toilets, and sleeping quarters. Clearly, these are inappropriate for use at reservoir sites. The danger to the water of such intensive surface use is too great, particularly if portable toilets are present. This does not mean the sport should never be permitted, however.

The older method of ice fishing, involving simply a hole in the ice and a chair, is compatible with reservoir management. No structures should be left on the ice overnight, and fishing should terminate at dark. Lightweight shelters, carried onto the ice daily and removed at night, may be allowed.

Portable toilets must be absolutely prohibited. Ice fishing must be confined to areas served by on-shore winterized toilets. No refuse may be allowed to accumulate on the ice, so on-shore facilities must also include well-maintained trash receptacles.

As with warm-weather fishing, local terminal reservoirs may attract a disproportionate number of casual participants who may not behave responsibly. More distant sites will attract more devoted enthusiasts whose conduct is likely to be better. For this reason it may be administratively simpler and more popular in the long run to permit ice fishing only on major storage reservoirs.

Snowmobiling Snowmobiling is a new sport which has achieved sizeable popularity in a very short time. Unfortunately, it is basically incompatible with all other forms of winter recreation. Many non-participants find the noise of snowmobiles very offensive. Snowmobiles can be a significant physical hazard as well. Traveling at high speeds, the vehicles can overtake skiiers and pedestrians before their drivers have time to take adequate evasive action.

The compatibility problems of snowmobiles are even more difficult than those of powerboating. Snowmobiles can travel cross-country virtually without restriction; fences are easily and frequently breached. In many areas sportsmen and property owners have had bitter disputes with snowmobilers over access to the woods. However, given the popularity of the sport, planners must give careful consideration to snowmobiles. Compatibility can be achieved if special areas are set aside for their use. At the larger reservoir sites, snowmobiling may be instituted without conflict with other sports if good planning is carried out.

The great majority of users enjoy long cross-country trails, ideally between 15 and 25 miles long. These should be arranged, as are other trails, to circuit around to their original starting point. At highly developed recreation areas it may be possible to put bridle paths to winter use as snowmobile trails. All trails must, of course, be marked at a level above the snow, and they must be separated as much as possible from trails used by skiiers, hikers, and snowshoers.

In addition to trails, open fields are necessary for warm-up and competition. These will receive hard use, and may require grooming from time to time. Managers must remember that if the snow depth is less than four inches, the vehicles can do substantial harm to the environment. In clearing any area for snowmobile use, it is also necessary to remember to plan for heavy snow: clearing height should be at least ten feet above normal snow height.

Snowmobiles should not be allowed on the reservoir ice. Reservoir intakes can make the ice treacherously thin in places, and the speed with which the vehicles travel can make errors in judgment easy. Falling through the ice is not only extremely dangerous for the driver, but is an obvious source of water pollution as well.

The ideal location for snowmobile activity is in a shallow geological depression surrounded by trees. This minimizes the noise problem. Steep slopes or cliffs can reflect noise, and the vehicles should be kept away from them. The reservoir surface is also accoustically reflective and snowmobiles should not be operated adjacent to it. Figure 16 shows a layout to minimize snowmobile noise problems.

The following regulations are suggested as the minimal ones required for a controlled snowmobiling program at or near reservoirs. Others may be required for local conditions and

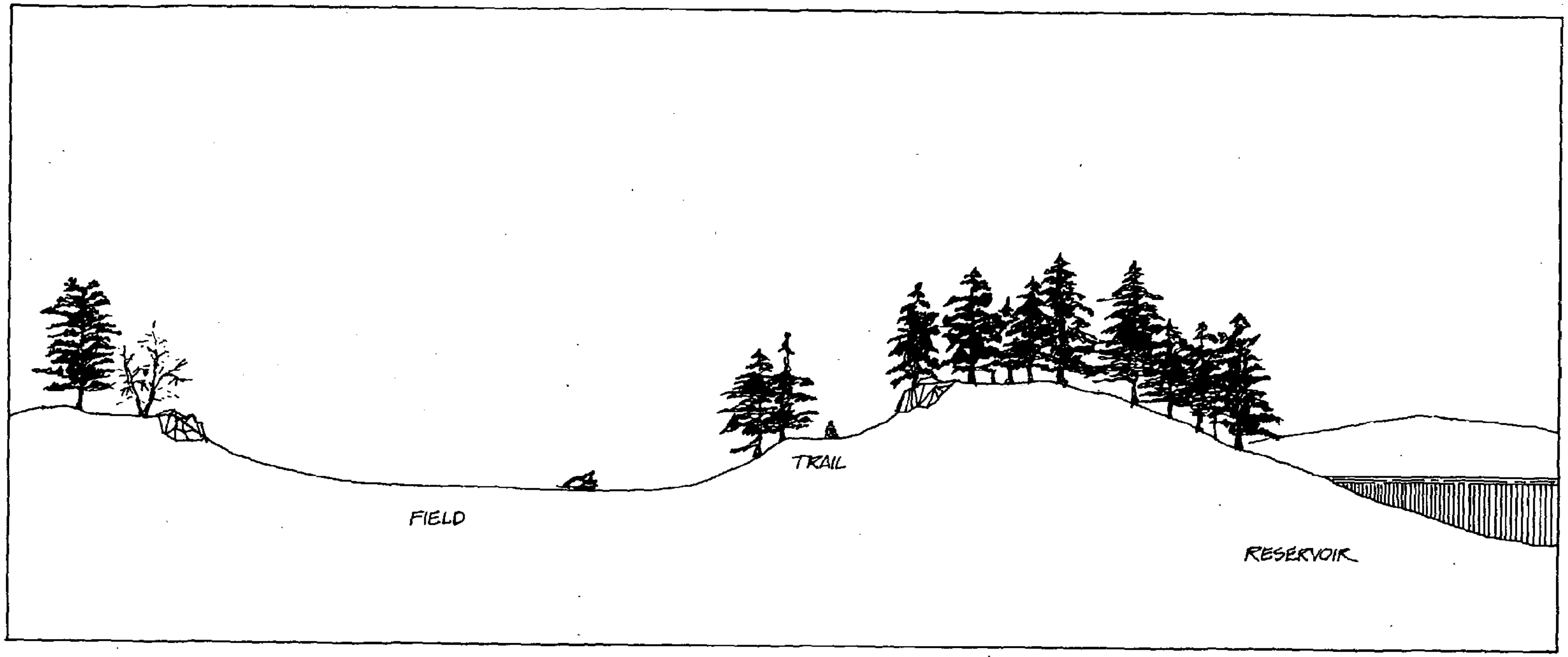


Figure 16
Planning for Reduction of Snowmobile Noise

to meet particular state codes:

1 Snowmobiling is permitted only on the snowmobile trails or routes as designated.
2 All other motorized vehicles not designed to be driven exclusively on snow or ice or both such as all-terrain vehicles, mini-bikes, motorcycles, trail bikes, and other vehicles of a similar nature are not permitted within the reservoir land boundaries.
3 Snowmobiles shall be equipped with working headlights, tail lights, brakes, and proper mufflers as supplied by the motor manufacturer.
4 Snowmobiles shall not be operated at any time in any manner, intended or reasonably to be expected, to harass, drive, or pursue any wildlife.
5 No person shall litter or dispose of trash or garbage along the snowmobile trails.
6 Snowmobiles shall not be operated on reservoir ice.

Support Facilities

A number of support facilities can contribute to the quality of reservoir recreation. However, this section is concerned with only the most basic support facilities, not with concessions or other discretionary ones.

Parking Lots At local recreation sites where a number of transportation modes service demand, it is not necessary to size parking lots for the maximum expected parking demand. A certain degree of parking congestion is tolerable since it serves to ration recreation space in favor of pedestrians and public transit users. Local sites can become highly congested on weekends and during the summer, and it is better to have congested access than congested facility, particularly at a reservoir site. Since average site visits are short and distances traveled are small, recreationists can simply return at another time of day when the crowding is less severe.

At sites not served by public transit it is important to have enough parking space to accommodate demand. Limitation of parking space should not be used as a mechanism to control access, since frustrated people who have driven to the site will simply park along public roads and cause a more difficult problem. Entrance fees can, however, be used to limit demand if that is desired.

It is not always possible, however, to build convenient parking lots big enough to handle maximum peak loads. There are usually a few weekends every year, such as around July 4 and Labor Day, when crowds are significantly bigger than at any other time. For such crowds temporary parking lots can be set up at some distance away from the central facility. Although these are less convenient for users, they do accommodate demand in an orderly and inexpensive manner.

Sanitary Facilities Plumbing and sanitary facilities are perhaps the most essential requirement for opening reservoirs to public recreation. The only situation in which public lavatories are not required is at a site within the developed urbanized area, where no boating or water contact is permitted and the average visit to the site is short.

The number and type of sanitation facilities may be specified by state health codes. Otherwise, the guidelines presented in Figure 17 can be used for

Figure 17

Required Sanitation Facilities

Male Bathhouse

# of Males	# of toilets	# of urinals	#of lavatories	#of showers	#of change rooms
1-50	1	1	1	1	1
51-100	1	1	1	1	1
101-250	2	2	2	3	4
251-500	2	3	2	4	6
501-750	3	3	3	4	7
751-1000	3	4	3	5	8
1001-1500	4	5	4	6	10
1501-2000	5	6	5	7	12

Female Bathhouse

# of Females	# of toilets	# of lavatories	# of showers	# of change rooms
1-50	1	1	1	1
51-100	2	1	2	2
101-250	3	2	3	4
251-500	5	2	4	6
501-750	6	3	4	8
751-1000	7	3	5	9
1001-1500	9	5	6	11
1501-2000	11	5	7	13

Source: George Fogg, *Park Planning Guidelines*, op. cit.

Figure 18
Minimum Radii of Protection Around Water Intakes

Reservoir Type	No Filtration: No Water-Based Activities	No Filtration: Water-Based Activities	Filtration: No Water-Based Activities	Filtration: Water-Based Activities
Terminal	Fence around intake facilities	N.A.	Fence around intake facilities	1000 ft. radius over water, fence around intake facilities
Collection	Fence around intake facilities	1 mile radius over water, fence around intake facilities	Fence around intake facilities	Fence around intake facilities, 500 ft. radius over water or whatever radius is necessary to protect recreationalists from local turbulence of water draw-off

Source: Urban Systems Research & Engineering, Inc.

planning purposes. This table should be used with the planned activities in mind. For swimming, all types of facilities may be required. For fishing, boating and other similar activities, showers and change rooms could be eliminated.

Protection of the Water Intake

The protected radius to be established around the water intake of a new or expanded recreation facility must be established specifically for each site. Topography, water inflow rates, water withdrawal rates, and similar local conditions can be as important in determining a protection radius as are intensity of recreational use, degree of available water treatment, and absolute size of the reservoir.

With respect to recreation, the function of a protected radius is first physical, to protect water intake facilities from tampering, and second water quality related, to increase the *effective residence time of possible* contamination and to reduce turbidity.

All reservoirs must physically protect their intakes with screens to prevent clogging by small fish and debris. These screens must, in turn, be protected against tampering by fencing *off the area directly around the water* intake, on land and in the water. With minimal treatment (i.e., chlorination only) it has been the practice to establish a very large protected radius, usually about two miles, around the water intake if boating is allowed. Access to the shore is cut off for a comparable distance on either side of the intake. With higher levels of treatment, and especially on system storage reservoirs, the protected radius may be cut down substantially. On the smaller terminal reservoirs the minimum *restricted distance around a* water intake is set to allow for maximum dilution of water used for recreation. A 30-day residence time for all *terminal reservoir water is desirable.*

The above table (Figure 18) offers a first approximation of minimum radii of protection. Planners must consult with their local water manager to determine a practical one for their site.

Public Abuse of Facilities

Vandalism There is legitimate fear that vandalism can pose a substantial threat to the water supply, and that recreation should be limited or curtailed because of it. There have been several incidents of vandalism at reservoir areas which have posed a threat to the water supply, and they should not be minimized. In one such instance, vandals took a portable toilet at a fishing area and threw it into the water. In all probability, this would have no effect on the quality of the finished water if the reservoir were large and the treatment adequate and reliable. The danger of a serious disease outbreak is obvious, however, if the treatment is unreliable.

Vandalism of toilet facilities is the most significant danger and is quite easily prevented. Portable toilets should not be used at reservoir areas, and supervision of permanent facilities should be careful. Other common acts of vandalism — destruction and defacing of equipment, throwing of glass, wood, and metal into the water, etc. — are common to most recreation areas and are not directly dangerous to water quality. Park patrols can reduce the number of incidents, and careful design can reduce the cost of the damages.

Littering Littering differs from vandalism only in degree. The American public is notoriously sloppy in its treatment of public facilities. This kind of abuse is often more disgusting to water managers than outright vandalism, for it violates all the tenets of watershed management. They find it hard to believe that the consumers of the water can show so little concern for their water supply. Although most littering will have no bacteriological effect on the water some kinds can. Improper disposal of food containers and disposable sanitary items, like baby diapers, could lead to such contamination.

Littering must be countered by provision of adequate waste containers. The public grounds must be tended routinely to pick up garbage left by park users. The full expense of this maintenance must be incorporated into the operating budget of the facility. Littering fines should be imposed and enforced. Except at the largest areas, food concessions should not be permitted.

Attendance at Site

Estimating the level of use, or demand, for recreation at the reservoir site is important for effective facility planning. These demand forecasts can help answer important questions about increased recreational use of water supply reservoirs: Is there a need for more recreation facilities in the area? What are the benefits of opening a new site? Is a specific plan feasible in terms of over- or under-capacity? Can the plan be financed out of user charges, or is subsidy necessary?

Recreation demand is usually described in terms of user-days per year. A user-day is counted when a person spends any part of a day at the facility. Thus, day trips accrue a single user-day for each visitor. The number of user-days that can be expected at a new facility has been found to depend on a number of factors including:

- **Total population** of the area
- **Income, education, age, and leisure time** of the population
- **Accessibility** of the site
- **Activities available** at the site
- **Quality** of the site
- **Cost**

Other factors may influence demand for recreation as well. The existence of other recreation opportunities will reduce the demand for a new site. Conversely, places with few alternatives will find recreation at water supply reservoirs particularly attractive. Water supply reservoirs can offer activities in a natural setting that may not be available elsewhere.

If the methods outlined below do not indicate adequate demand, it may still be beneficial to open the reservoir to recreation. Demand for recreation builds over time. After a site is opened, it can take several years to reach its full potential because people are slow to learn about its existence, location and facilities. Population growth, increased leisure time, and growing income contribute to a long term increase in recreational usage over time. In addition, a new facility can create its own demand, particularly if it is unique or offers unusually high quality recreation.

If demand does not appear adequate to construct a large facility, recreation can be phased in. Low cost activities, such as fishing, hunting, and hiking can be permitted initially. Then, as demand builds, boating, swimming, and other activities can be planned, and the necessary facilities constructed.

In the past thirty years, considerable research has focused on estimating the demand for outdoor recreation. The results of these studies can be used in planning recreation activities at water supply reservoirs. Simple methods based on one or only a few of the factors listed above may be adequate for most planning. More complex techniques which consider in detail all these factors may be required in unusual circumstances or when large scale recreation development is planned. Three approaches to demand estimation are described below.

Population Ratios Method

The total demand for recreation activities can be estimated from the population in the area. This procedure requires three pieces of information. First, the area in question needs to be defined. Second, the size of the population must be known. Third, the ratio of population to user-days in each activity is required. Total demand is then calculated by multiplying the population by the activity ratio.

The area a recreation facility can serve depends on the types of activities offered. A city reservoir clearly draws visitors from a smaller area than does the Grand Canyon. Many activities considered in this handbook such as swimming, boating and fishing, can be enjoyed in day trips. The demand area is then the distance a family could travel for a day outing. The quality of local roads and public transportation affect this distance. In general, people residing in counties and towns within 50 miles of a site could use it for day recreation.

The population of the cities, towns and counties in an area can be found from several sources. The U.S. Bureau of Census publishes this information every 10 years. That volume may be available at local libraries or town governments. Regional planning agencies may also have this data, and may have more recent population estimates.

Population use ratios for major activities are presented in Figure 19. Total area demand for each activity can be calculated from these coefficients by multiplying the area population by the appropriate figure in the table.

Part of that demand may be cur-

Figure 19

Population-Use Ratios for Selected Activities: Northeast Region

Activity	User-day/person over 14 years of age
Total Outdoor Recreation	69.0
Swimming	11.4
Boating	2.4
Fishing	2.3
Walking for pleasure/nature walks	14.9
Bicycling	7.9
Birdwatching/photography	3.6
Outdoor games or sports	14.2
Picnicking	3.5
Horseback riding	.7
Camping	1.9

Source: *1970 Survey of Outdoor Recreation Activities,* U.S. Department of Interior, Bureau of Outdoor Recreation, February 1972.

rently met by existing facilities. Therefore, the demand for the new facility may not equal the total demand. But many people may find the new facility more attractive, so demand for that facility is greater than the difference between total demand and current recreation capacity. To determine more accurately the demand for the new site, more sophisticated techniques, such as those discussed below, should be employed.

Similar Site Method

Similar recreation sites in the same area can be expected to attract similar levels of use.[2] If there is any unmet demand in the area, then this fact can be used to estimate the demand at a new site.

Care must be taken in comparing sites to utilize this method. Site characteristics which must be compared include:

Accessibility
Activities available
Quality
Cost

To the extent sites differ in these respects, use can be expected to differ. Subjective judgments can be used to adjust use figures at a known site to project use at a new site. Guidelines for these judgments are presented below.

Accessibility can be defined more precisely as the amount of time and discomfort involved in reaching the recreation site. On one hand, this term refers to the type of roads available, distance between parking facilities and the site, and so on. On the other, it refers to the distribution of the service population; the further they are from a recreation site, the lower accessability. In general, all else equal, a less accessible site will attract fewer people. A doubling in the time required to reach a site will reduce demand at that site from one-half to one-fifth of the use that would otherwise be expected.

The range of recreational activities available will obviously influence the number of people desiring to use a facility. The previous section presents figures for forecasting demand for each activity. In the context of "similar site" demand forecasting, those figures can be usefully employed to adjust demand according to the activities available. Demand at the known site is first broken down by activity using the ratios in Figure 19. Then adjustment in demand at the new facility can be made. For example, if twice as much space for swimming is provided at the new site, that component of demand at the comparison site should be doubled to make the forecast. Similarly, if swimming is not permitted at the new site, that component of demand at the comparison site is subtracted out of the forecast.

Quality factors are both highly subjective and difficult to quantify. For example, some find beach crowding annoying while others view it as an integral part of the recreation experience. However, a well-maintained, litter-free park is likely to attract more visitors than one that is poorly cared for. The magnitude of this effect is not clear, and the appropriate adjustment factor must be based on local considerations.

Finally, the cost of the recreation experience will affect demand. Cost factors are partly considered in accessibility and activities. User-charges in the form of admission fees and parking fees will tend to discourage potential users. The difference in user charges as compared to known site should be considered. Empirical estimates of the effect of cost difference on demand vary considerably. Some research had indicated that a 1% higher cost results in no change in demand, and others predict up to a 3% reduction in demand. All else equal, the higher figure is likely to be more accurate. By establishing higher fees at more popular sites, this effect of price on demand can be used to divert demand from overused areas to less well-known ones.

Statistical Methods

The two sections above outline simple "rule of thumb" methods for estimating the use at a facility planned. In the past decade several more sophisticated forecasting techniques have been developed and used in planning recreation. These techniques purport greater accuracy but also are considerably more expensive to implement. For the purpose of planning vast recreation facilities such as National Parks, Corps of Engineer reservoirs, etc., they may be warranted. Because of the manpower and analytic skills required, they are, in large, unavailable to the users of this handbook. However, if the necessary resources are available, the two techniques described below may be useful adjuncts to the methods discussed previously.

Potential users of the planned facility can be interviewed directly to determine their recreational preference and possible level of use. Current users of existing facilities as well as the area's population might be queried. At the same time that potential demand is determined, it would be easy to determine preferences for facilities, activities and user charge systems. This line of demand forecasting is similar to consumer product market research, used by many businesses, and the same problems of sample selection and questionnaire design exist. Several of the references in the bibliography can help guide the interested reader.

The second sophisticated technique available for predicting use of a new facility involves explicitly accounting for the various factors which influence demand. Data on (1) demand at various existing sites, and (2) the site characteristics listed in the sections above is collected. Statistical techniques are available to cull from this information relationships between population, site characteristics, and demand. These relationships can then be used to project demand at the new facility. References in the bibliography can help guide the interested reader.

Who Will Use the Facilities?

One of the special values of opening reservoir land to increased recreation is that reservoirs are generally located close to urban areas where the need for recreation is great. Because they have been shielded from urban development, they provide a kind of experience which one must go to the distant countryside to duplicate. This means that those who have little opportunity to leave the city can enjoy something which has been excluded from their lives before.

Two groups which will especially benefit from recreational opportunities on nearby reservoirs are the poor and the elderly. The young and the middle class will also use the facilities, but they also have the option to travel to other places for recreation.

In addition to being an argument in favor of opening the reservoirs to the public, this consideration also suggests they should be left largely in their present natural state. While there are multiple opportunities to engage in team sports and other recreation which requires a high level of activity and patronage, reservoirs are best developed for recreation which gains value by being quiet and private. One does not need to forecast an enormous attendance at a proposed facility in order to justify it; in fact, overuse of such a facility would diminish its value for those who visit it as well as its value for water supply.

To serve the poor and the elderly by opening reservoirs, planners must anticipate the problem of subsidizing the costs of the facilities. Ordinarily, it is most equitable to ask each user to pay a fair share of the costs of the recreational facility. If water users pay the cost of recreation (through higher water rates) the charges are levied on those who do not necessarily use the facilities. Free passes could be provided to especially disadvantaged groups, but the cost of this subsidy would be borne by other recreationists. If recreation is to be enjoyed by those who cannot afford to pay a user charge, some other private or public agency should subsidize their recreation. The water company itself would not likely want to underwrite such an expense. The question of user charges is discussed in greater detail in "Costs and Financing" below.

To a certain extent, the type of facility developed will determine the type of user. Reservoir sites, if developed for quiet, low density, secluded swimming activities, will tend to attract swimmers who are actually very compatible with the objectives of reservoir water management. Professional people and others of comparatively high socio-economic status can be expected to seek out the natural environment of reservoir sites. Younger people, such as teenagers and college students, tend to prefer beaches which are crowded and active, and so would be less apt to congregate at a reservoir facility in large numbers. Beaches with distinct entrances and boundaries, and which can be surveyed from a cruising car, are especially attractive to teenagers, as are sites with food concessions. By eliminating such features from a reservoir recreation area, the site can be designed to attract users who are most compatible with the objective of the recreation planned.

Recreation Costs and Financing

Plans for increasing recreation at a public water supply reservoir should include estimates of all the costs involved, including capital expenditures, operations and maintenance costs, and alternative methods for financing. In this section, costs are broken down into five areas: costs of water treatment, costs of recreation facilities, costs of staff and maintenance, financing techniques, and finally, the calculation of benefits associated with these costs.

Costs of Water Treatment

Recreation planners must consider the costs of various water treatment processes because the level of recreation possible at a reservoir site is linked to the water treatment available. Virtually all public water systems use chlorination to disinfect the water before distribution; the costs of chlorination equipment presented in this section are given primarily as reference information. Every water supply reservoir should already use chlorination or some other form of disinfection. The main emphasis of this section is on filtration equipment and the incremental costs of additional treatment if recreation is expanded. Filtration equipment is much more expensive to install and operate than chlorination equipment, and recreation might be called upon to bear some of the costs of improved water treatment.

Currently the construction industry is experiencing rapid cost inflation. When budgets are estimated, the dollar costs presented here should be modified upward to account for this. The Construction Cost Index and the Labor Cost Index published in the periodical *Engineering News Record* can be used for this purpose.

Relationship Between Plant Output and Community Size For planning purposes, the amount of water a person uses in a day is usually estimated at 125 gallons. The first estimate of required plant output could then be found by multiplying the population served by 125 gallons per capita per day.

Two other factors must be considered, however. First, a certain amount of water is lost in transmission. Water companies generally bill for 90-95% of the water which leaves the plant. Second, industrial and commercial uses of water must be added to the total figure. These are seldom accurately known. General practice is to revise the per capita use figure upwards to include system leakages, and industrial and commercial use. In areas which are not heavily industrialized, water use will probably be between 100 gpcd (gallons per capita per day) and 200 gpcd.

In this section costs are calculated by plant output rather than by population, since to assign a service population to a plant size would require fixing on a certain level of per capita consumption. The best way to estimate the true use of water in an area is to ask the local water manager. The true use may be as low as 60 gpcd or as high as 200 gpcd if significant industry is present. In an area without substantial industry or commercial development, 125 gpcd would be a useful first guess.

Chlorination Chlorination is the cheapest water treatment process commonly used. All that is needed is a regulating chlorinator and a holding basin to assure minimum contact time. The cost of treatment is related primarily to the volume of water distributed, not to the amount of chlorine required. While recreation may increase the required chlorine dose, the increase in costs associated with this difference will be small. No additional equipment would be required in order to permit increased recreation.

The present cost of chlorine is about $.20 per pound. If recreation increased chlorine demand, the added cost of chlorine per million gallons of water per additional milligram per liter of chlorine required would be about $1.66. Increased chlorine costs required to permit recreation will probably be less than $4 per million gallons. Clearly, this is a small additional cost.

Figure 20 presents representative present costs of chlorination.

Filtration Under present standards, chlorination is considered adequate treatment unless the turbidity level of the water exceeds 5 JTU (Jackson Turbidity Units) or the bacterial loads are greater than 50 per 100 milliliters of water. Beyond that, coagulant-assisted (rapid) filtration is generally used. EPA's proposed new standards would lower permissible turbidity level to 1 JTU, which would mean that filtration would be almost universally required at surface water sources.

Filtration is more expensive than chlorination since storage volume must be sufficient to hold water for two hours of treatment. Overall treatment costs for the two basic filtration processes are presented in Figure 20. The figures are adjusted to account for inflation. It is clear from Figure 20 that the slow sand filtration process is not competitive with the coagulant assisted rapid sand process, even though its capital costs are lower. Cleaning of the filter beds requires manually scraping off the top layer of sand and replacing it which is a very costly maintenance process. Slow sand filtration may be useful in certain special localities, however.

Sample Cost Calculations Let us take the example of a moderate sized community of 40,000 people. Its water system includes chlorination equipment, but to meet the new Federal Safe Drinking Water Standards a filtration plant must be built. Since the community wants to get the most out of its investment it decides to allow swimming and other recreational activities at the reservoir site. It is determined that this will require an additional chlorine dose of 1 milligram per liter during the summer months when swimming is allowed (120 days per year).

Per capita water use in the community is estimated at 110 gpcd, meaning plant output will be about 4.5 MGD. To allow for moderate growth the community decides on a

5 MGD plant.

Costs then can be estimated as follows:

5 MGD Rapid Filtration System	Capital Costs	Annual Costs
Coagulation/Sedimentation	$ 930,000	$ 81,000
O/M		202,000
Rapid Sand Filter	583,000	51,000
O/M		225,000
Extra Chlorination for recreation: $.66 milligram MGD Day/liter		996
x 5 MGD x 1 milligram/1 liter x 120 days =	1,513,000	559,996

This translates into an annual cost of $14.00 per capita for the initial population. The debt payments will remain constant through the years, but O/M costs may rise due to inflation. The additional chlorine costs, which are the only ones directly attributable to recreation at the site, are a negligible $996 per year. In this case a user charge for recreation could easily pay off these costs and could also contribute substantially to reducing the burden of the filtration plant costs on the water users.

Calculations of costs for other situations are equally straightforward.

Costs of Recreation Facilities

This section is meant to help the reader make a useful but preliminary estimate of the costs to be expected in developing or expanding a recreation area. Of course, precise costs should be estimated prior to construction. Competent professional assistance should be sought to help design and budget the facility. The local recreation and parks department could provide this expertise.

Detailed cost estimates can be derived from the appropriate annual edition of *Building Construction Cost Data* by Robert Snow Means Company, Inc., Duxbury, Massachusetts. This book is a standard reference widely used in the construction industry for bid estimation, but must be used with care. It is updated every year to consider increases in material and labor costs, and since costs vary from city to city, the Means Company provides an index multiplier for major U.S. cities. It must be remembered when using books like Means that figures supplied are usually exclusive of contractor's overhead, profit and contingencies.

Figure 20
Costs of Water Treatment Processes

Process/Plant Size (MGD)	Chlorination: Capital Costs (per annum)	Coagulation Sedimentation: Capital Costs (per annum)	Coagulation Sedimentation: Operations/ Maintenance (per annum)	Rapid Sand Filtration: Capital Costs (per annum)
.5	8000 (700)	161,000 (14,000)	20,000	122,000 (10,700)
1	10,500 (900)	270,000 (23,500)	40,000	193,000 (16,900)
2	14,600 (1300)	461,000 (40,200)	81,000	313,000 (25,300)
5	25,000 (2200)	930,000 (81,000)	202,000	583,000 (51,000)
10	42,800 (3700)	1,580,000 (137,700)	404,000	934,000 (81,300)
20	74,000 (6500)	2,680,000 (233,700)	808,000	1,500,000 (131,300)

Rapid Sand Filtration: Operations/ Maintenance (per annum)	Rapid Filter System: Annual Total Costs	Slow Sand Filtration: Capital Costs (per annum)	Slow Sand Filtration: Operations/ Maintenance (per annum)	Slow Sand System: Total Annual Cost
34,000	58,700	233,000 (20,000)	63,000	83,000
63,000	103,400	375,000 (32,700)	126,000	158,700
144,000	209,500	622,000 (54,000)	253,000	307,000
275,000	407,000	1,190,000 (104,000)	632,000	736,000
515,000	734,000	1,943,000 (170,000)	1,264,000	1,434,000
972,000	1,337,000	3,187,000 (278,000)	2,529,000	2,807,000

Figure 20 presents the costs of various treatment processes. The source for the figures presented here is the report "Monograph on the Effectiveness and Costs of Water Treatment Processes for the Removal of Specific Contaminants," by the Environmental Planning and Engineering Division of David Volkert and Associates, Bethesda, Maryland, August 1974. The following comments about the figures' accuracy should be made. Costs have been adjusted upwards by the rate of inflation in the building industry over the period between October 1973 and June 1975. Capital costs were increased 15.4%, based on the Construction Cost Index; labor rates were increased by 17.2%, based on the Labor Cost Index averaged between skilled and unskilled labor.

Annual costs were calculated according to the conventional formula:

$$C_a = q \frac{i}{1 - (1 + i)^{-n}}$$

where:

q = principal
i = interest rate = 6%
n = term in years = 20

Typical Costs

Item	Cost (Dollars)
Site Development: The clearing of roads, parking lots, and building sites is the first expense to be incurred. Costs vary according to density of growth to be removed.	
No trees	700 (per acre)
Light growth (6" trees)	1,300
Medium growth (10" trees)	1,800
Heavy growth (16" trees)	2,300+
Roads, Parking Lots, Trails: Road costs vary widely. Costs depend on who does the work — a local DPW may be cheaper than a commercial construction firm.	
Roads:	
50' Right of Way	34,000 (per 1000')
26' Two land road	
Parking Lots:	
Per space, including share of maneuvering room. (based on 10 x 20 foot space)	
Unpaved	500 (per space)
Paved	1,200
Trails:	
Includes cost of clearing and grading:	6,000 (per mile)

Item	Cost (Dollars)
Bikeways:	
8' paved bikeway, including cost of clearing	20,000 (per mile)
Fence:	
Chain link fencing is ordinarily used to protect the water from unauthorized access.	
6' chain link fence (galvanized)	8 (per linear foot)
Building Construction: These figures are a rough guide to lightweight building construction.	
Unheated sheds, porches, etc.	15-18 (per square foot)
Unheated bathhouses, offices and similar construction	18-25 (per square foot)
as above heated	25-45
Specific Facilities: Some average costs for frequently planned facilities are presented below.	
All-weather toilet facility	20,000-35,000
4-bay maintenance building	100,000
Beachhouse (dressing rooms, bathrooms, concession, first aid, lifeguard)	160,000
8 x 10 foot tollbooth	2,000
Children's playground equipment (swings, see-saw, slides, etc.)	2,000
Dock	6-11 (per square foot) 1,600-2,600 (per boat slip)
Boat launching ramp	7,000
Golf Course (includes clubhouse, parking, etc.)	1,200,000
average cost per hole	25,000
Picnic area (and share of fireplaces)	75 (per table)
Trash can	15

Sample Estimations

1) Small Area Consider the development of a small terminal reservoir to which there is no present access. Low intensity activities on the adjacent land are all that is contemplated. A circuit path around the reservoir and several acres of clearing will be major expenses. The water will have to be fenced off from public access since no body contact with the water is desired. Parking will be provided for 100 cars.

Item	Cost
Road: 1000'	$ 35,000
Parking: 100 cars	120,000
Clearing: 5 acres	10,000
Bikeway: 2 miles	40,000
Fence: 2 miles	42,500
Playground equipment:	2,000
Picnic tables: 4	300
Miscellaneous: trash cans, signs, etc.	1,000
	$250,800

This estimation assumes that no capital expenditures for maintenance equipment would be necessary. On a small terminal reservoir, it is likely that the municipal department of public works could provide trucks and machinery on a cooperative basis.

An annualized cost for this facility, assuming a 6% interest rate and a 20 year term, would be $250,800 x .0872/annum or $21,869 per annum.

2) Large Area The development of a major storage reservoir for several activities would be a substantial project. Included would be a full-scale bathhouse facility and swimming beach, boat docks and launching ramps, trails for snowmobiling and hiking, bikeways, picnic areas, and parking for 500 cars.

Item	Cost
Road: 5000'	$ 175,000
Parking: 500 cars	600,000
Clearing: 30 acres	60,000
Bikeways: 5 miles	100,000
Trails: 25 miles	150,000
Fencing: misc. 2000'	16,000
Bathhouse:	160,000
Beach: 4 acres @ same cost as clearing	8,000
Dock: 20 boats @ $2000/slip	40,000
1000 sq. ft. courtesy dock	10,000
Boats: 20 @ $400 (12' with 10 hp. motor)	8,000
Launching Ramps: 3	21,000
Picnic Tables: 100	7,500
Comfort Stations: 2 @ $25,000	50,000
Miscellaneous:	5,000
	$1,410,000
Maintenance Shed: (if required)	100,000
Maintenance Equipment: (if required)	30,000
	$1,540,000

The figures for maintenance equipment are estimated by assuming two large trucks at $10,000 and one pick up truck at $5,000 are necessary, as well as $5,000 worth of miscellaneous equipment such as lawn mowers, plowing attachments, cultivators, tillers, etc.

The annualized cost of this facility, assuming the same 6% interest rate and 20 year term, would be $134,288.

Discussion It is interesting that the greatest single expense in each instance is parking facilities. Parking lot costs may be reduced by more than half if the lot is left unpaved. Continued regrading costs may make this a false economy, however. Runoff from an unpaved parking lot may also contribute to reservoir siltation. At large areas where lots can be located at a distance from the water and where winter use is not intense, unpaved parking lots may be a reasonable choice.

In the larger areas, it is reasonable to assume that a parking charge will be levied. This can more than cover the amortization of the capital expenditure for parking, and can contribute considerable revenue to the expenses of the rest of the facility. Likewise, the bathhouses and boating facilities at large areas will be self-supporting through user charges.

Staff Costs

Operation and maintenance of a recreation facility includes a wide variety of expenses. In addition to labor the facility operator must pay for vehicles, repair materials, fuel, insurance, and so on. The excellent publications of the National Recreation and Parks Association (1601 North Kent Street, Arlington, Virginia 22209) discuss these expenses of park operations; this section of the handbook analyzes the staff costs which are likely to be incurred.

Typically a park requires a unit manager, maintenance personnel, patrolmen, and support staff for specific activities planned. Guidelines for the personnel needed are discussed below. Figure 21 presents a common pay scale for these labor classes.

A park director is only needed at the largest sites. In many cases, responsibility for park management can rest with the water supply manager's office. This arrangement is desirable to encourage adequate planning for protection of the water, and to help allay fears of the managers that recreation will violate their professional standards. Otherwise, park management can be accomplished through the local parks and recreation department, possibly by the manager of some other nearby park. In either case, for all but the smallest sites, additional funds should be provided to the managing agency to pay at least a part-time salary.

The number of maintenance personnel required will depend on the size of the site, the activities permitted, and extent of facilities needing upkeep. Maintenance is best accomplished through the local park maintenance system. If the site is large, additional personnel may be needed. In addition to a full time custodian, one or two men are needed, on average for every 50 acres of developed land. This level of staffing should be adequate for lawn mowing, trash removal, litter pickup, facility maintenance, and minor road repair work. Unless extensive winter activities are planned, most maintenance costs will be incurred during summer months. During that season staff requirements can double the guidelines stated above. Hiring students on summer vacation can be an effective method for meeting this demand.

Enforcement of park regulations, and general maintenance of public safety is important to control recreation. Patrols should match usage. In any case, an urban park should be patrolled daily. In parks of moderate use, five patrols each day is a minimum adequate level. On days of intensive usage, such as Labor Day, Memorial Day, July 4th policemen should be on duty full time. During winter months when use has diminished, lower levels of patrol, perhaps once or twice a week, could be maintained.

Park enforcement should be planned to complement the recreation activities. Horseback and foot patrols are suitable for large sites. During winter months, snowmobiles or skiis could be used. Many parks use local police for these patrols. Uniformed rangers could accomplish much the same purpose. These personnel could, in addition to enforcing park regulations and aiding those in distress, lead nature walks, guide hikes and bird watching tours, and otherwise enhance enjoyment of the natural setting provided by reservoir recreation.

Finally, personnel may be required to support some of the specific activities planned. For swimming, state laws may require certified lifeguards to be present. Some state regulations govern

Figure 21
Typical Staff Salaries

Job	Weekly Salary Range
Park Manager	\$175-\$350
Assistant Manager	\$145-\$200
Skilled Laborer	\$200-\$400 (union rate)
Maintenance Laborer	\$100-\$150
Life Guard	\$125-\$150
Facility Clerk	\$115-\$140

Source: Urban Systems Research & Engineering, Inc.

the number of lifeguards needed. Otherwise, there should be one lifeguard for every 400 feet of beach at a minimum, but one lifeguard can only supervise 100 beach users. If many of the people on the beach are very young or old, or are known to be unskilled swimmers, more lifeguards should be provided, up to one for every 50 beach users.

Finally, some facilities will require an attendant. Boat rental concessions should have at least one for every 75 boats. A riding stable or snack bar will need staff. The exact requirements can be estimated from the plan developed.

Cost Recovery and Financing

A major issue in planning increased use is financing the costs associated with facility development. The costs of recreation can be divided into capital costs and operating costs. Capital costs are the costs of buying land, building facilities, and in the case of reservoir recreation, sometimes building or expanding treatment plants. Operating costs include the base cost of operating facilities, plus the marginal cost of operation and maintenance imposed by each additional visitor.

A simple example would be the case of a small rowboat and motor rented to fishermen. The cost of the boat and motor themselves would be the capital cost; the cost of hiring a rental agent and some inevitable maintenance like yearly painting would be the operating cost; and the fuel, oil, and engine maintenance would be the marginal operating cost imposed by each visitor. Sources of funds to meet these costs is the subject of this section.

General Tax Revenue is one source of money for facilities. It has the advantage that it is reviewed annually by the governing body, but the disadvantage that it is not directly related to the amount of use a facility gets. The problem of annual budget review is raised, and getting the appropriation in the first place may be difficult.

Bond Issues are another method. A general bond is paid for out of state or local revenues, but is approved once and for all by the legislature or through a referendum, obviating yearly review. The disadvantage is the equity issue — a general bond forces people who may not use the facility to pay the costs for those who do. A revenue bond, on the other hand, is paid for out of charges collected at the site. While equitable, it may not encourage the best facilities. High charges will reduce demand, and there will be incentive to install minimal facilities with the greatest possible commercial return. The result might be inadequate and inappropriate facilities.

Grants-in-Aid may be obtained from a higher branch of government, federal or state. These grants usually cover only capital costs; operating and maintenance costs must be paid for by the administrating local government. Such grants are, of course, paid for by state or local taxes, raising the equity argument again.

User Charges can be imposed to pay off revenue bonds or simply to pay operation and maintenance costs. While these are very efficient — costs are borne directly by the beneficiaries — they may tend to discourage would-be users who cannot afford the charge.

Ideally the user charge should reflect the added cost of recreation. To calculate the charge, the basic operating and maintenance costs of the facility should be added to the increased operating costs of water treatment and the marginal expenses which will be imposed by the expected demand. This sum should be divided by the estimated number of paying visitors to determine the daily use charge.

This charge can be imposed as an entrance fee, a parking fee, or as a charge for a specific activity, such as swimming. The costs of administering the charge should be considered in establishing the fee system. For example, entrance or parking fees may be easier and less costly to administer than swimming fees, if there are few entrances to the park and a large number of swimming places. Conversely, if there are many access points but only a few beaches, swimming fees may be appropriate.

Additional factors to consider in establishing a user charge are discussed below.

Effect of a User Charge on Demand
Attendance can be expected to decrease from 0 to 3% for every 1% rise in price. The difficulty is in predicting the change in demand between having no entrance fee and having an entrance

fee. For purposes of planning, it can probably be assumed that demand at a new facility will probably be insensitive to a small user charge, and the similar-site method of predicting demand would be applicable even if the existing site has no user charge and the new site has a low charge.

Reservoir sites are almost always more attractive to recreation than other water bodies close to cities on which indiscriminate recreation is allowed. For recreation areas accessible primarily by automobile, which characteristically includes reservoirs, it can be assumed that ownership of a car implies ability to pay.

It is reasonable to assume that activities such as fishing, boating, snowmobiling, cross country skiing, and the like, for which the user incurs high costs for equipment, will be less sensitive to entrance charges. Similarly, activities like hiking, swimming, picnicking, and bird watching, which require some degree of preparation and committment, will also be less sensitive to charges within a reasonable range. It is casual attendance for no specific purpose which will be most sensitive to user charges. Reservoir recreation areas will have a comparatively low percentage of such use, which is more typical of urban parks.

Other Effects of User Charges User charges are good for a variety of other purposes besides providing revenue. They can regulate crowding, reduce abuse of the facility, promote investment in private and specialized recreation resources, and be set up to encourage use by particular segments of the population.

In an area mainly used on the weekend, crowding can be a problem. It can be advantageous to have a higher user charge for weekends than weekdays, thus encouraging a more even distribution of demand over the week. If attendance is extremely low over the week and very high on weekends, there could be no charge Monday through Friday. This would drastically cut administrative expenses of collecting the fee and enable low income users to get free access to the facilities.

Charging a fee also encourages more responsible use of a facility. Many people will be more careful of littering if they are forced to pay for recreation, and the payment will enable the park to maintain higher standards, which in themselves encourage responsible behavior.

Within the park, additional user fees can be collected for use of special facilities. Parking fees, swimming fees, boat rentals, and bathhouse fees are common examples.

Finally, user charges can be set up to encourage or discourage use by certain groups. Residents of the local town, for example, can be favored by free admission or a reduced charge. Occasionally it is desired to discourage certain people from using the site, such as weekend visitors from other towns. Local preference systems can be administered through passes or car stickers.

Costs and Benefits

Decisions concerning the investment of public funds are commonly analyzed by comparing the expected costs of the project with the expected benefits. If the benefits exceed the costs, then the project should be built.

The calculation of costs has been presented in the sections above, and involves facility costs, land acquisition costs, management and operations, and (possibly) the increased operating expenses of water treatment. The assessment of these costs is straightforward.

Recreation provides a number of benefits for those who participate. These include the joy of being outdoors, the exhilaration of exercise, and the opportunity for peaceful contemplation of nature. Those who do not currently participate in recreation receive benefits from the potential use of the site and through its conservation. Total benefits equal the sum of the benefits of each individual. While it is difficult to estimate benefits to the same degree of specificity as costs, still it is possible to evaluate these intangible qualities in dollar terms.

A simple way to evaluate the costs and benefits of recreation is to divide the costs of development by the total number of expected user days. This figure represents the total cost per user day. The question can then be asked "Is it worth that many dollars for each user day to have this recreational opportunity?" It may be useful also to divide the total cost by the population of the town or municipality which will pay for it and enjoy its benefits. The investment question can then be asked as, "Is it worth that many dollars per person to expand local recreational opportunities?"

The Federal Government uses a similar technique in planning its water resources development.[3] The total number of user days are estimated and then multiplied by a dollar value per user-day to obtain the total recreation benefits. The value per user day depends on the available amount of swimming, picnicking, boating, and fishing. User-days for these activities are valued from \$.75 to \$2.25 (1974 dollars). For specialized activities where other opportunities are limited, intensity of use is low, and large personal expense is required, values from \$2.50 to \$7.00 per user day are used. Hunting and some types of fishing and boating are examples of these more valuable types of recreation.

Increased recreation is likely to provide other benefits in addition to those stemming from the direct use of the new facilities. In presenting a case for increased recreation, these benefits should be assessed as well.

The most immediate secondary benefit will be relief of congestion on other recreational facilities. This can mean the gradual upgrading of local recreational facilities, and can diminish public abuse of properties which are frustratingly congested.

Peripheral commercial development around the recreation area may also occur, providing services which may not be available, or should not be available, inside the park. Restaurants and snack bars are good examples. Sales of sporting goods, such as fishing equipment, gasoline, ice, and so on are likely to be stimulated locally, and residential property values may increase. However, the locality must be prepared to exercise control over development which might be induced around the new recreation facility; land use problems may result if it fails in this responsibility.

The expansion of recreational facilities near major population centers can provide significant benefits to the poor, elderly, and otherwise disadvantaged. These groups traditionally have inadequate access to existing recreation opportunities, particularly those offering the quasi-natural settings of many domestic water supply reservoirs.

Legal, Social and Institutional Factors

At any reservoir site there are likely to be a number of legal and political constraints on recreation development which may cause the level of recreation to fall short of the optimum. Some such constraints are rigid, such as laws which expressly forbid certain types of recreation. Others can be modified over time, such as adverse public perception of recreation based on misinformation. The institutional arrangements for providing water supplies can be a barrier to increased recreation. In this section, laws, regulations, public and professional opinion, and institutions are discussed as they relate to the planning process.

Laws

Many states have laws which limit or prohibit certain activities on reservoirs and watersheds. In planning for recreation, planners must familiarize themselves with pertinent state laws regulating water supplies, watersheds, and recreation. A summary of pertinent laws and regulations for the six states covered in this handbook is contained in Chapter 2. Several states have laws restricting swimming in reservoirs, but they differ widely: some prohibit swimming entirely, others specify conditions under which swimming may be permitted, and still others delegate the authority to restrict swimming to local water managers. While swimming is the most commonly regulated activity on drinking water reservoirs, some states laws affect boating, fishing, and other forms of recreation.

Activities on reservoir watersheds are also the subject of legislation. Many states grant powers to their Departments of Health to control sewerage facilities on watersheds, and some states are considering more general controls on development to prevent the discharge of hazardous materials. Watershed controls tend to be aimed at physical structures and their support facilities, not at recreational activities.

Some laws affect recreation more generally. For instance, many states regulate snowmobiles and require registration of boats. Every state licenses hunters and fishermen. Such regulations must be considered in any recreation plan.

Codes and Regulations Some state agencies have adopted codes and promulgated regulations which have a strong impact on recreational activities. Most important are the public health codes and the public safety codes. Codes may be changed under the authority of the original enabling legislation whenever the regulating agency deems it wise; they are more flexible than laws, which have to be amended or repealed by action of the state legislature. Because they are flexible, the codes operate on a level of detail which broad legislation does not, and may require that planners adhere to very specific and rigid standards. The design of certain support facilities such as bathhouses may be covered in detail in state health codes, and fishing and hunting are closely regulated by Fish and Game Departments, which also have the power to license participants. Planners must closely study the relevant state codes to make sure facility planning conforms to the regulations.

In some cases, recreation activities which are covered in broad legislation may also be covered by detailed agency regulations. For example, in Massachusetts, the prohibition against swimming is carried both as a law (Chapter 111, Section 172) and as a Department of Public Health regulation (under Chapter 111, Section 160). To allow swimming in Massachusetts would require changes both in law and the Department of Public Health regulations.

Planners cannot predicate their designs upon an expectation of a change in either laws or regulations, but they ought to petition for changes where existing restrictions are outdated or unreasonable.

Public Opinion

Public opinion can be a useful force to enlist in the planning process, but it can also act capriciously. While increasing public recreation opportunities is a popular goal, planners may encounter unexpected opposition for two basic reasons: the public may fear its effect on water quality or anticipate adverse social and economic effects.

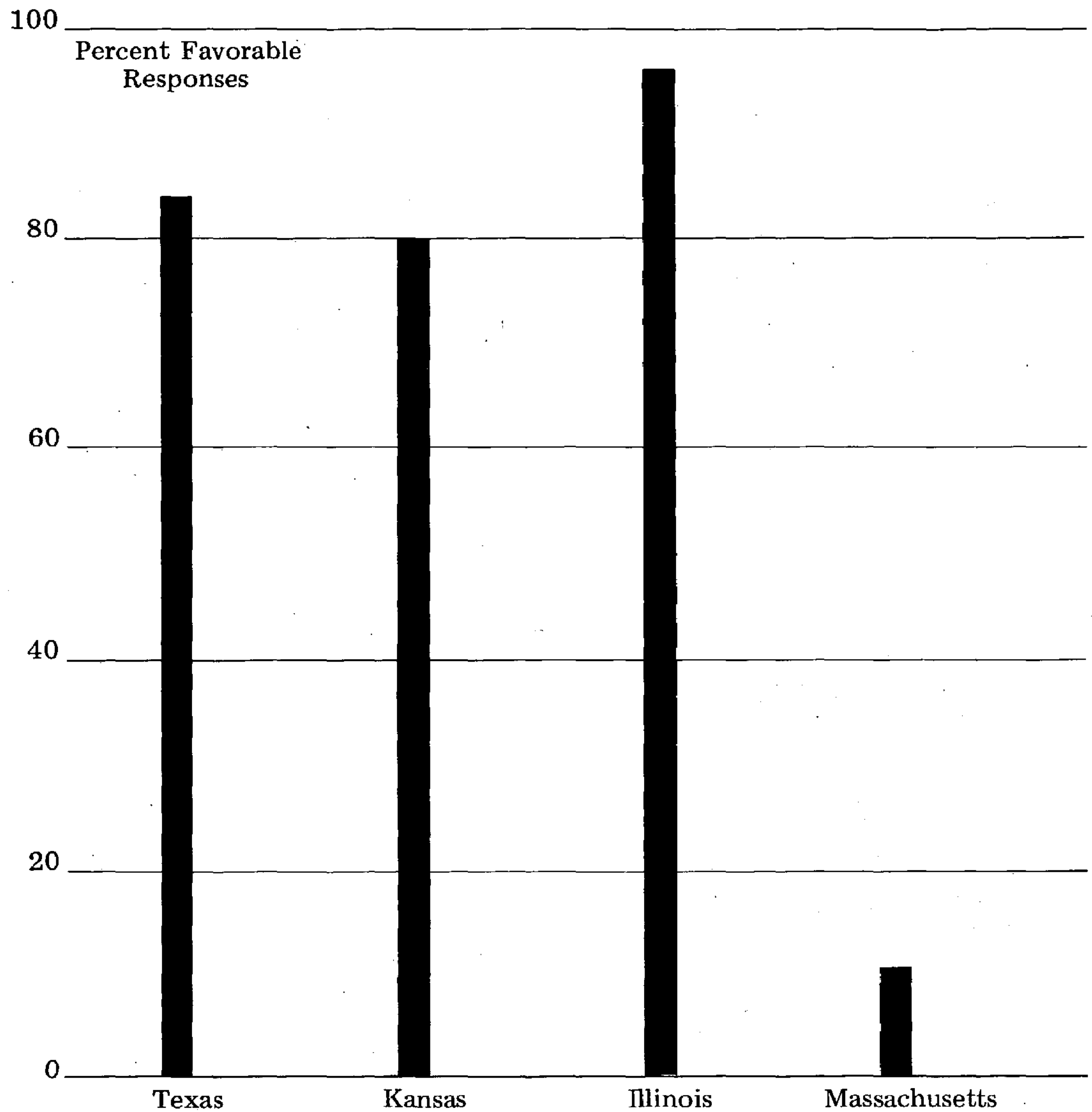
Public Perceptions of Water Quality Issues On the basis of interviews, it has been found that public perception of the health issue largely parallels the attitudes of regional managers and that both reflect the influence of the traditional regional attitudes toward reservoir recreation.

Figure 22 shows positive public attitudes toward reservoirs as recorded in four states. Where recreation is generally permitted, the public perceives it as desirable; where it is not, public acceptance is low. In states where reservoir recreation is generally permitted, people tended to perceive no relationship between the quality of drinking water and recreational activities. In Massachusetts, however, 66% felt that recreation on water supply reservoirs impairs drinking water quality.

The important question is, can negative attitudes change? The answer is clearly yes. Many organized groups in the Northeast vigorously advocate increased recreation opportunities on reservoirs. Fishermen are the most active and successful. Enough successful examples of reservoir recreation exist in the Northeast to be the basis of a widespread change in public attitudes.

Public opposition to recreation can also be based on a perception of threats to other values. This is particularly true in situations where a site which long closed to the public is opened up. In rural areas, residents may be anxious about an influx of people arriving from outside. Residents of properties adjoining the reservoir may fear that property values will be lowered by public recreation. They may also fear vandalism to their own property. Those with attractive views of the reservoir may worry that recreational activities will spoil it. Residents whose direct interests may be affected by recreation should be invited

Figure 22
Consumer Preference for Recreation on Domestic Water Supply Reservoirs



Source: Baumann, op. cit.

to participate in the entire planning process.

Institutional Factors

Traditionally water supply managers have had no incentive to permit increased recreation. Recreation is not one of their agency's goals. Recreation could lead to added costs. New responsibilities could mean new problems. In some cases, the presence of recreation could expose the water managers to criminal liabilities in the event of a failure in the quality of water supplied. Often they see recreation to be new problems and new costs, with no reward.

This resistence should be considered in building a case for increased recreation. The water manager should be involved in planning to achieve mutual understanding and assure that water supply problems are adequately taken into account. Care should be taken that the water supply budget is not used for recreation development; if the recreation is to be managed by the water supply agency, then more money and new staff should be provided. While it may not be possible to create an incentive for water supply managers to encourage recreation on water supply reservoirs, at least the traditional disincentives can be removed by careful planning.

Professional Opinion

There are several professional organizations whose opinions of recreational activities on water supply reservoirs carry weight. In the Northeast, the two most prominent are the American Water Works Association, a national organization, and the New England Water Works Association. Traditionally, both advocated restrictive policies. The AWWA, however, has revised its policy regarding recreation to favor greater multiple use, reconciling the points of view of the various parts of the country, most of which permit such recreation. The New England Water Works Association still firmly opposes recreation

In May of 1958, the AWWA published a formal statement on reservoir recreation in its Journal. The statement drew distinctions between permissable recreation levels on various types of reservoirs, but firmly rejected recreation on all terminal reservoirs and on storage reservoirs with very high quality water.

The statement was based on the degree of treatment which the water would receive. Class A reservoirs, those with very high water quality typical in New England, were presumed to receive only minimal disinfection. Some recreation was considered permissable on Class B reservoirs, which required "treatment in varying degrees in addition to disinfection," and more recreation could be allowed on Class C reservoirs, which required "complete treatment." In its conclusion the statement opposed all legislation which would take jurisdiction over permission for recreation away from the water manager.

As a result of new studies contesting the validity of recreational restrictions, and in order to incorporate the disparate views of water managers in various parts of the country, the AWWA recognizes that full treatment permits any and all forms of recreation on most reservoirs; its reservation is that Class A reservoirs (virtually all Northeastern reservoirs are Class A) have no need for filtration, and, therefore, should permit no recreation. There is abundant evidence, however, that controlled levels of body contact recreation do not degrade Class A water in large reservoirs.

The New England Water Works Association is considerably more conservative than the AWWA on the issue of reservoir recreation. In September of 1958 they published in their Journal a "Final Report of the Committee on Recreational Uses of Public Water Supplies." It said in part:

> "Trying to pollute to a safe limit. . . has no place in a safe sanitary consideration." (P. 411)

In the March 1971 Journal, the Committee on Recreational Use of Public Water Supplies issued a lengthy statement of the case against reservoir recreation, derived from the existing literature on the subject. It recounted the various famous instances of disease outbreaks, and quoted the California Fact Finding Committee on Public Health:

> [W]e commonly have every year many epidemics of respiratory and gastrointestinal infections. . . These gastrointestinal and respiratory infections are just the kind of conditions that can be caused by viruses escaping all safeguards in a water supply system subject to human contamination at the source and retaining virulence right into the home, restaurant, or hospital water tap."

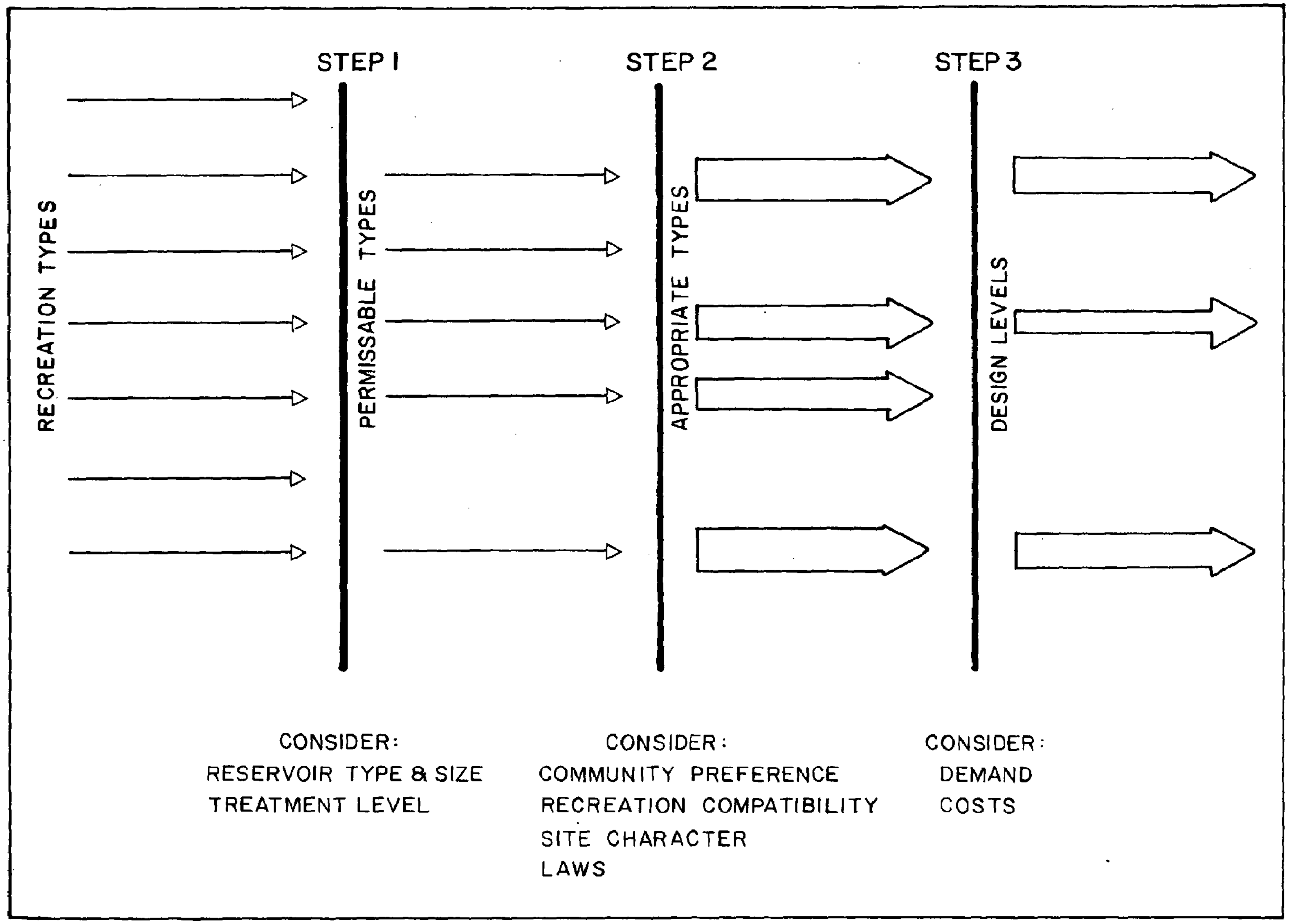
Perhaps the most telling sections of the report deal with the objectionable practices of recreationists and vandalism at public water supplies. Episodes of defecation on the watershed, garbage and toilet contents being thrown overboard from boats, and destruction of sanitary facilities by vandals were documented.

The report concluded with the following quotation from J.P. Hennings, of the Portland Water District in Maine.

> "Although water-based recreation represents a growing social need and reservoirs in many cases provide suitable media for such activity, the many problems associated with public access for recreational purposes warrant careful deliberation before modifying present policy. Attention should be given to the possibilities of meeting recreational demands through the development of other water areas."

This report effectively sums up the arguments against increased recreation on water supply reservoirs. It can be faulted, however, as it demonstrates only that water treatment should be of a higher grade for all surface water supplies. Many of the instances of abuse occurred as a result of illegal entry into watersheds. What should not be minimized by any group planning for increased recreation is the Committee's finding that the American public often behaves in a slovenly and shameful manner in public places. This underlines the necessity adequate maintenance and supervision of recreation, but it does not justify the exclusion of the public from reservoir areas.

Figure 23
Flow Diagram of Recreation Decision Making Process



Determining the Best Level of Use

To create an actual design for a facility, all the factors discussed in this planning section must be brought together. The following factors are involved:

- **Size** of Reservoir
- **Type** of Reservoir
- **Treatment Capability** of Water System
- **Community Preferences**
- **Characteristics** of Site
- **Types** and **Compatability** of Desired Recreation
- **Laws**
- **Demand**
- **Institutional Constraints**
- **Cost and Financing**

The flow diagram in Figure 23 describes the decision-making process. Three basic screening steps are involved. In the first, the types of permissable recreation at a specific site are identified. Next, appropriate types of recreation are decided upon, and a maximum level of activity set for each. Finally, the appropriate types are quantified and designed into a workable system.

Step 1: Permissable Recreation

The first step in the process is to eliminate recreational activities which are incompatible with the reservoir's primary function to supply safe water. Figures 24 and 25 offer a preliminary guide in selecting permissable recreation activities according to the size and type of the reservoir and the available level of treatment. The term "game sports" includes tennis, baseball, and other activities which require structured playing, but not golf, which requires careful planning of a large course.

Size and Type of Reservoir A reservoir's size and type are related to its assimilative capacity for natural or man-made wastes. The total ability of the water system to handle contamination includes both natural and artificial purification systems.

Collection reservoirs generally have a larger natural assimilation capacity than terminal reservoirs since the average residence time of the water is greater. Most enteric viruses and bacteria do not survive in open water longer than thirty days, and the residence time of collection reservoirs is virtually always much longer. However a distinction is drawn between collection reservoirs over five square miles in area and those smaller than that. While factors such as shoreline length and depth are also important considerations, the five square mile figure represents the approximate upper limit of moderate size reservoirs. In the Northeastern states, reservoirs larger than this tend to be substantially larger, and can accommodate more intensive recreation with only moderate treatment due to their greater and more predictable assimilative capacity.

Estimating an area figure for approximating residence time is not a reliable procedure for terminal reservoirs due to their complex water handling operations. Especially in metropolitan water systems, the exchange of water in terminal reservoirs can be deceptively rapid. For this reason, terminal reservoirs are classified in Figure 25 as those with greater than thirty days residence time and those with less. The average residence time at any reservoir can be obtained by consulting the local water manager.

Level of Treatment For the purpose of recreation planning, four levels of treatment can be identified; technical descriptions of these processes are supplied in Chapters One and Four. "Plain" chlorination, in which the disinfecting residual is not closely monitored, is most common in small rural systems and is a less sophisticated technique than free residual chlorination, in which the amount of chlorine in the free state is monitored and maintained to a standard. Free residual chlorination permits greater amounts of recreation. Filtration with free residual chlorination, which many experts feel should be the standard level of treatment for all surface water sources, permits most types of recreation on most reservoirs so long as treatment is reliably maintained and recreation activities adequately supervised.

Sophisticated filtration processes may further extend recreation possibilities where tastes and odors may be a problem. Other treatment processes which are not aimed at enhancing the biological quality of the water, such as iron and manganese removal, do not affect the permissable level of recreation.

Figures 24 and 25 provide a guide

Reservoir Size	Plain Chlorination	Free Residual Chlorination	Filtration and Free Residual Chlorination	Activated Carbon or Other Advanced Process
Small: <5 sq. miles		fishing boating (no motor) sailboating	fishing boating (small motor) sailboating	fishing boating (small motor) sailboating
	informal land based recreation hiking, game sports picnicking, hunting bicycling, golf	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding golf	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding camping, golf	informal land based recreation hiking, game sports picknicking, hunting bicycling, riding camping, golf
	informal winter land based recreation cross country skiing snowshoeing ice skating (semi-artificial rink) snowmobiling	informal winter land based recreation cross country skiing snowshoeing ice skating (semi-artificial rink) snowmobiling	informal winter land based recreation cross country skiing snowshoeing ice skating (semi-artificial rink) snowmobiling	informal winter land based recreation cross country skiing snowshoeing ice skating (semi-artificial rink) snowmobiling
	(no access to shore)	(controlled access to shore)		
Large: >5 sq. miles		fishing boating (small motor) sailboating swimming	fishing boating (any size motor) sailboating swimming	fishing boating (any size motor) sailboating swimming
	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding golf	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding camping, golf	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding camping, golf	informal land based recreation hiking, game sports picnicking, hunting bicycling, riding camping, golf
	informal land based winter recreation cross country skiing snowshoeing, snowmobiling ice skating (semi-artificial rink)	informal land based winter recreation cross country skiing showshoeing, snowmobiling ice skating (semi-artificial rink)	informal land based winter recreation cross country skiing showshoeing, snowmobiling ice skating (semi-artificial rink)	informal land based winter recreation cross country skiing snowshoeing, snowmobiling ice skating (semi-artificial rink)
	(no access to shore)	(controlled access to shore)		

Figure 24
Permissable Recreation at Collection Reservoirs

Source:
Urban Systems Research & Engineering, Inc.

for selecting permissable recreation activities. Local circumstances may affect the selection to some degree.

Step 2: Appropriate Recreation

The next step is to select appropriate recreation activities from the group of permissable ones, and to set an initial level of activity for each. Levels of activity may be defined intuitively, by such terms as intense, moderate or minimal, or can be quantified in terms of number of picnic tables, acres of lawn, or the like. Selection should reflect community preferences, compatibility of activities, site characteristics, opportunities available at nearby sites, and laws.

Community preferences are not difficult to analyze, provided planners are aware of the size of the area from which visitors will come. A facility serving a local community may differ from one which draws visitors from a metropolitan area. Expensive facilities such as golf courses or riding facilities should only be proposed when adequate demonstrated demand for them exists within the community group to be served.

Compatibility problems have been described earlier in connection with individual activities. If any activity is planned which is known to create noise or safety hazards, the layout must be planned with care.

The site itself will suggest some activities and eliminate others. Slope, drainage, water table, and types of vegetation are among factors to be considered. Aesthetic aspects of the site are very important. In undisturbed areas the wilderness value of a site is especially valuable, justifying restriction on the types of activities and the level of public access.

Planners should be aware of the facilities of nearby recreation areas, and should seek to complement them rather than compete with them. Reservoirs are likely to offer opportunities for special recreation activities, and these should be exploited whenever possible.

Lastly, a few activities, such as swimming, are likely to be controlled or prohibited at reservoir sites. All relevant laws should be investigated in the initial stage.

Step 3: Preliminary Plan

Development of the preliminary plan requires consideration of demand and costs. Use of the similar site method will be appropriate to estimate the demand at all but the largest sites. Activities with limited demand may be eliminated at this time, with the expectation that they could be provided later when use of the site increases. On the other hand, a variety of recreation possibilities, even on a modest scale, may make the site more successful than if only common activities, like picnicking and general recreation, are permitted.

The costs of the facilities will be the last major planning question. Recreation activities which require a high level of supervision or maintenance may for that reason have to be rejected. Similarly, the planned level of recreation may have to be considerably less than the maximum amount the site could support. Bicycle paths or hiking trails may have to be shortened, picnic areas reduced in size, and facilities moderated to an acceptable cost level.

User charges must be calculated, and the financing scheme for capital costs and operations designed. The availability of grants or loans must be researched, and the cooperation of various groups and institutions negotiated. Professional expertise may be helpful in this step, and a local parks and recreation department may be able to assist in final plan development.

Reservoir Size:	Plain Chlorination	Free Residual Chlorination	Filtration and Free Residual Chlorination	Activated Carbon or Other Advaned Process
Small: Residence Time < 30 Days			fishing boating (no motor)	fishing boating (no motor sailboating swimming
	informal land based recreation	informal land based recreation hiking hunting picnicking bicycling game sports	informal land based recreation hiking hunting picnicking bicycling game sports golf	informal land based recreation hiking hunting picnicking bicycling game sports golf
	informal land based winter recreation	informal land based winter recreation cross country skiing snowshoeing ice skating (on reservoir) snowmobiling	informal land based winter recreation cross country skiing snowshoeing ice skating snowmobiling ice fishing	informal land based winter recreation cross country skiing snowshoeing ice skating snowmobiling ice fishing
	(no access to shore)	(controlled access to shore)		
Large: Residence Time> 30 Days		fishing (from shore)	fishing boating (no motor) sailboating swimming	fishing boating (small motor) sailboating swimming
	informal land based recreation hiking hunting picnicking team sports	informal land based recreation hiking hunting picnicking bicycling game sports	informal land based recreation hiking hunting picnicking bicycling game sports camping riding golf	informal land based recreation hiking hunting picnicking bicycling game sports camping riding golf
	informal land based winter recreation cross country skiing snowshoeing ice skating (semi-artificial rink) snowmobiling	informal land based winter recreation cross country skiing snowshoeing ice skating (on reservoir) snowmobiling ice fishing	informal land based winter recreation cross country skiing snowshoeing ice skating (on reservoir) snowmobiling ice fishing	informal land based winter recreation cross country skiing snowshoeing ice skating (on reservoir) snowmobiling ice fishing
	(no access to shore)	(controlled access to shore)		

Figure 25
Permissable Recreation at Terminal Reservoirs

Source:
Urban Systems Research & Engineering, Inc.

Appendix I
The Effectiveness of Modern Water Treatment in Removing Pathogenic Organisms

Water treatment was established to protect the public from several severe enteric illnesses, most of which are uncommon today. These include typhoid, paratyphoid (salmonellosis), dysentery (shigellosis) and cholera. However, the reduction in morbidity rates from these diseases is not solely the achievement of treatment of public water supplies. Vaccinations, pasteurization of milk, and similar public health measures are also responsible.

All water-borne diseases are also food-borne or contact transmitted, so even perfect protection against pathogens in public water supplies cannot eliminate the diseases they cause. Although there are well documented cases of diseases transmitted through public water supply systems, low grade endemic illnesses are more frequently transmitted by contaminated food or through deficient sanitary conditions in the home or in public places.

The most common objection against reservoir recreation, particularly where body contact with the water is involved, has been the public health issue. We have maintained that common fears of reservoir recreation exaggerate the true risks, and this section of the handbook is devoted to documenting that claim. As a result, the technical content of this section is detailed. It has been reviewed by prominent sanitary engineers, however, and should counter any technical objections local water managers may have to proposed recreation plans.

The U.S. Public Health Standard for coliform organisms in drinking water is as follows:

Drinking Water Standards, 1962

3.2 Limits — The presence of organisms of the coliform group as indicated by samples examined shall not exceed the following limits:

3.21 When 10 ml standard portions are examined, not more than 10 percent in any month shall show the presence of the coliform group. The presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs:

(a) In two consecutive samples;

(b) In more than one sample per month when less than 20 are examined per month; or

(c) In more than 5 percent of the samples when 20 or more are examined per month.

When organisms of the coliform group occur in 3 or more of the 10 ml portions of a single standard sample, daily samples from the same sample point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

3.22 When 100 ml standard portions are examined, not more than 60 percent in any month shall show the presence of the coliform group. The presence of the coliform group in all five of the 100 ml portions of a standard sample shall not be allowable if this occurs:

(a) In two consecutive samples;

(b) In more than one sample per month when less than five are examined per month; or

(c) In more than 20 percent of the samples when five or more are examined per month.

When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

3.23 When the membrane filter technique is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3/50 ml, 4/100 ml, 7/200 ml, or 13/500 ml in:

(a) Two consecutive samples;

(b) More than one standard sample when less than 20 are examined per month; or

(c) More than five percent of the standard samples when 20 or more are examined per month.

When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

Bacteria

The standard indicator for pathogenic bacteria in water is the coliform bacteria group, itself benign. Since it is found in all human fecal samples, the presence of coliform bacteria in water is taken as presumptive evidence of contamination by human wastes, and it is presumed that pathogenic bateria which can exist in the digestive tract will also be present.

While the statistical risk of disease associated with detection of coliform organisms is greater according to the size of the population responsible for the contamination, the probability of pathogenic organisms with just one individual discharge is already too great to be ignored.

The number of coliform bacteria excreted every day by one person is very large, on the order of hundreds of millions. Dilution of these bacteria in large water bodies is so substantial, however, that counts in a protected reservoir are virtually zero. For example, even in a heavily used lake, like Sebago in Maine, average counts from the most contaminated sections — the local tributary streams — are about 315 per 100 ml.[1] Figure 26 shows the effectiveness of the treatment processes described in Chapter 1 in removing E. coli bacteria,[2] one member of the coliform group.

None of the techniques listed in Figure 26 can meet these standards without additional disinfection, except in rare circumstances with vary high quality raw water. While there are some examples of communities which filter their reservoir water but have no

Figure 26
Effectiveness of Treatment in Removing E. Coli

Type of Treatment	% Effective	Circumstances
Pre-treatment Settlement	99.9	5 days at 28°C (sample from Ohio River) 11 days at 4°C (sample from Ohio River)
Coagulation	99.9	1st stage: $Al_2(SO_4)_3$ as coagulant, final pH 6.7-7.4 2nd stage: $FeCl_3$ as coagulant, final pH 7.3-7.7
Filtration	(min) 90	Flocculation & Rapid Filtration of floc suspensions through floc impregnated filter in 30" white sand (0.425 mm.)
	(max) 98	Flocculation & Rapid Filtration of supernate, 30" of white sand (0.425 mm.)

Source: Figures extracted from: Gerald Berg, "Virus Transmission by Water Vehicle. III. Removal of Viruses by Water Treatment Procedures," *Laboratory Health Science*, Vol. 3, No. 3, (July 1966).

disinfection apparatus, this practice is considered unsound in theory and is found to be so in practice.[3]

In the United States, chlorination is the most popular disinfection technique.[4] Ozone, a more powerful disinfectant than chlorine, is not widely used because it is more costly to install and presents a potential hazard of explosion. Ozone also does not persist in the water, as chlorine does, so it cannot be used to safeguard the water as it flows through the distribution system.

Chlorine disinfection, like all disinfection processes, is highly sensitive to the water temperature; a 10°C rise in temperature will increase the rate of destruction by 200-300 percent.[5] The most effective form of chlorine against most pathogens, hypochlorous acid (HOCl), is sensitive to the pH of the water, and will ionize to form the much less effective hypochlorite ion (OCl^-) at pH levels above 7.

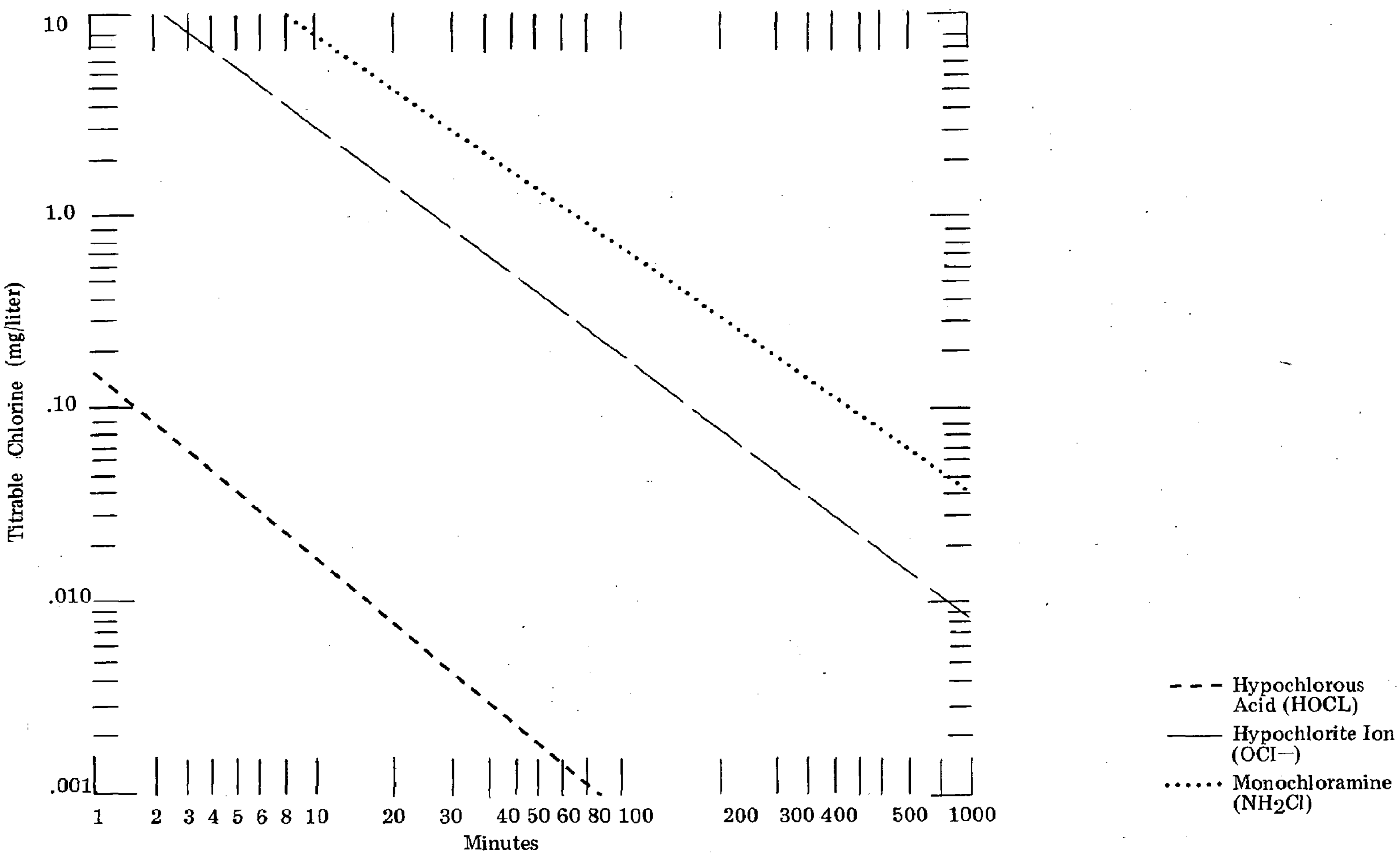
Furthermore, when ammonia or nitrogenous organic compounds are present, as they are in many natural waters, a further reaction takes place producing various chloramines, which are less effective disinfectants than hypochlorite ion against coliform organisms.

With these variables in mind, the following graph (Figure 27) is presented showing the effectiveness of the various chlorine forms at different contact times, at 2-6°C. Because disinfection efficiency decreases with temperature decline, low temperature results are the most significant.

Chlorination alone is permitted when initial coliform count is less than 50 per 100 ml. Processes by which the content of active chlorine in water is reduced are called the "chlorine demand;" the difference between the applied dose and the chlorine demand is the residual chlorine, and this provides an extra measure of safety in the distribution system. Whether chlorine by itself is sufficient treatment in a certain circumstance depends on many factors besides initial coliform count. Different temperatures, contact times, desired residuals, and water impurities will produce widely different required doses of chlorine.

In practice, virtually all surface water sources are disinfected by chlorine, or, rarely, ozonation. Though some protected reservoir sources may record zero coliform counts at the intake most of the time, a minimal dose of chlorine is added as a protective measure. However because pathogens may sometimes be sheltered from disinfection by being buried within a host organism passing into the distribution system, and because of the presence of viruses and other non-bacterial contaminants, the best practice is to utilize a coagulation/rapid filtration process in addition to adequate disinfection.

Figure 27
Chlorine Disinfection



Relationship between concentration and time for 99 percent destruction of E. coli by 3 forms of chlorine at 2-6°C.

Source: Berg, op. cit.

Viruses

Conventional water treatment techniques have proved their effectiveness in combatting water-borne bacterial diseases, but there is some worry that they are not sufficiently effective in removing viruses from the water. Some medical experts believe that continued low level exposure to viruses in the environment is actually in the public interest, as it helps to maintain a high level of immunity in the population, but this is not an acceptable policy in water quality management.

Viruses are very small particles; being between 6 and 550 nanometers (millimicrons) in diameter, they may only be seen through an electron microscope. Detection of viruses on a routine basis in water treatment plant operations is currently impossible. Despite admittedly unreliable correlations between the presence of coliform organisms and viruses in a water sample, the only estimate of viral contamination presently available are the standard coliform tests.

The common cold is the most familiar virus disease, but it is not waterborne. The so-called enteric viruses transmit infections through the digestive tract, and they can be waterborne. Today, the most notorious disease which has been known to be transmitted through public water supplies is infectious hepatitis,[6] which infects the liver. Because of its severity, heptatitis has received considerable attention in the field of public water supply. It has been seen to be on the rise in this country over the past several years, but it is hard to tell what is actually happening since the disease also has an endemic cycle with a periodicity of seven to eleven years. Yearly variations in the number of cases must be viewed against long-term trends to see if environmental safeguards are actually deteriorating.

Viruses are still inadequately understood. Of the enteric viruses — those entering the body by the oral route — those described in Figure 28 are documented as being actually or potentially water-borne.

Viruses are highly variable in their sensitivity to treatment processes. Many are more resistant to chemical disinfectant than bacteria are, but some are more sensitive, at least to HOCl. All seem to be about as sensitive to temperature as the enteric bacteria.

As with bacteria, treatment is of two basic types — removal and deactivation. Pre-treatment sedimentation is useful in reducing the number of active viruses in raw water. Both aging effects (environmental die-away) and actual sedimentation are involved with this process. Figure 29 shows the sensitivity of the process to temperature and substantiates that "sedimentation" is effective primarily through deactivation or death of the virus.

Long holding times are very expensive to achieve in practice. More rapid processes are necessary for high volume public water supplies. Figure 30 shows results of flocculation techniques at various temperatures, comparing Coxsackie virus removal to coliform bacteria removal.

The addition of coagulants to water

Figure 28
The Human Enteric Viruses That Can Be Waterborne and Known Diseases Associated With These Viruses

*Ascending type of muscular paralysis
**Mongolism
†Febre episode with sores in mouth
+Pleuritis type of pain with fever
††Rash and blisters on hand-foot-mouth with fever

Source: Floyd Taylor, "Viruses — What is their Significance in Water Supplies?" *Journal of the AWWA* (May 1974).

Group	Subgroup	No. of Types or Subtypes	Disease Entities Associated With These Viruses	Pathologic Changes in Patients
Enterovirus	Poliovirus	3	Muscular paralysis	Destruction of motor neurons
			Aseptic meningitis	Inflammation of meninges from virus
			Febtile episode	Viremia and viral multiplication
	Echo virus	34	Aseptic meningitis	Same as above
			Muscular paralysis	Same as above
			Guillain-Barre's Syndrome*	Destruction of motor neurons
			Exanthem	Dilation and rupture of blood vessels
			Respiratory diseases	Viral invasion of parenchymiatous of respiratory tracts and secondary inflammatory responses
			Diarrhea	Not well known
			Epidemic myalgia	Viral invasion of cells with secondary responses
			Pericarditis and myocarditis	
			Hepatitis	Same as above
	Coxsackie virus	>24	Herpaniginaϯ	Viral invasion of mucosa with secondary inflammatory responses
	A		Acute lymphatic pharyngitis	Same as above
			Aseptic meningitis	Same as above
			Muscular paralysis	Same as above
			Hand-foot-mouth diseaseϯϯ	Viral invasion of cells of skin of hands and feet and mucosa of mouth
			Respiratory disease	Same as above
			Infantile diarrhea	Viral invasion of cells of mucosa
			Hepatitis	Viral invasion of liver cells
			Pericarditis and myocarditis	Same as above
	B	6	Pieurodynia+	Viral invasion of muscle cells
			Aseptic meningitis	Same as above
			Muscular paralysis	Same as above
			Meningoencephalitis	Viral invasional invasion of cells
			Pericarditis, endocarditis, myocarditis	Same as above
			Respiratory diseases	Same as above
			Hepatitis or rash	Same as above
			Spontaneous abortion	Viral invasion of vascular cells(?)
			Insuin-dependent iabetes	Viral invasion of insulin producing cells
			Congenital heart anomalities	Viral invasion of muscle cells
Reo virus		6	Not well known	Not well known
Adenovirus		31	Respiratory disease	Same as above
			Acute conjunctivitis	Viral invasion of cells and secondary inflammatory responses
			Acute appendicitis	Viral invasion of mucosa cells
			Intussusception	Viral invasion of lymph nodes(?)
			Sub acute thyroiditis	Viral invasion of parenchyma cells
			Sarcoma in hamsters	Transformation of cells
Hepatitis		>2	Infectious hepatitis	Invasion of parenchyma cells
			Serum hepatitis	Invasion of parenchyma cells
			Down's Syndrome**	Invasion of cells

Figure 29
Effect of Pretreatment Sedimentation:
Laboratory Study Demonstrating Days Required for 99.9% Reduction of Viruses and Bacteria in Raw Waters

Number of days required Temperature °C	4		20		28	
Organism	Little Miami R.	Ohio R.	Little Miami R.	Ohio R.	Little Miami R.	Ohio R.
Poliovirus 1	27°C	19°C	20°C	13°C	17°C	11°C
Echovirus 7	26°C	15°C	16°C	7°C	12°C	5°C
Echovirus 12	33°C	19°C	12°C	5°C	5°C	3°C
Coxsackievirus A9	10°C	20°C	8°C	8°C	8°C	5°C
Aerobacter aerogenes	15°C	44°C	8°C	18°C	6°C	15°C
Escherichia coli	10°C	11°C	7°C	5°C	6°C	5°C
Streptococcus faecalis	17°C	57°C	8°C	18°C	6°C	9°C

Source: Berg, op.cit.

to reduce suspended debris and microorganisms can be highly successful. Clearly, a two-stage process achieves markedly better results, and the process is quite insensitive to water temperature. Other studies were not as encouraging as this one, however, and show percentage removals to be on the order of 40% rather than 99+%.[7] Furthermore, the procedures necessary to create good floc formation are exacting and, in actual practice, are unlikely to be realized on a routine basis.

Filtration by various techniques is another method for removing viruses from water. In slow filtration, fine sand particles are used (diameter about .28mm). A natural jelly-like substance forms on the sand and removes, by complicated chemical and mechanical processes, a large portion of the suspended particles in the water.

Despite its effectiveness, slow filtration is too expensive for high volume use today. The United States pioneered the rapid filtration process, and its efficiency in removing bacterial pathogens when used in conjunction with flocculation techniques is very good. Under optimum conditions, the process is also very effective in removing viruses. Figure 31 shows various performance levels of rapid filtration. In the (A) and (C) cases, adequate settling time is allowed so that most of the floc does not pass through the filter. In cases (B) and (D), the floc suspension itself is filtered, yielding lower efficiency in removing bacteria but equal efficiency in removing viruses.

Historically, flocculation and rapid filtration are viewed as one process, and this is justified by these results. One can argue, as Berg notes,[8] that with adequate settlement time, flocculation alone can achieve better results than flocculation/filtration with unsettled coagulated water. But he also warns that the flocculation/filtration procedure will be unsafe if the floc is not adequately formed, for it eventually may break through the filter if not sufficiently strong and carry virus with it.

In general, these studies show results based on laboratory standards of control which are not ordinarily achieved by most water treatment facilities. For this reason, it is probably not possible to accept the logic that flocculation alone is equally efficient in removing viruses, for unless the coagulated water is filtered microorganisms imbedded in floc may pass through the disinfection process without contact with the disinfectant.

Again, disinfection by various means is presently the only true safeguard against viruses and bacteria. In an analysis of the virus problem at the Windhoek Waste Water Reclamation Plant in South Africa, Nupen and Stander write:[9]

> Although virus is removed by flocculation, settling, sand filtration and carbon filtration to a high degree, final assurance for complete inactivation of virus must always be on disinfection; it is therefore essential to ensure break-point chlorination at all times.

Figure 32 shows the rate of destruction of viruses at various water temperatures, pH, and chlorine dose levels. Figure 33 shows necessary levels of chlorine for destruction of viruses according to time, temperature, pH, and water type.

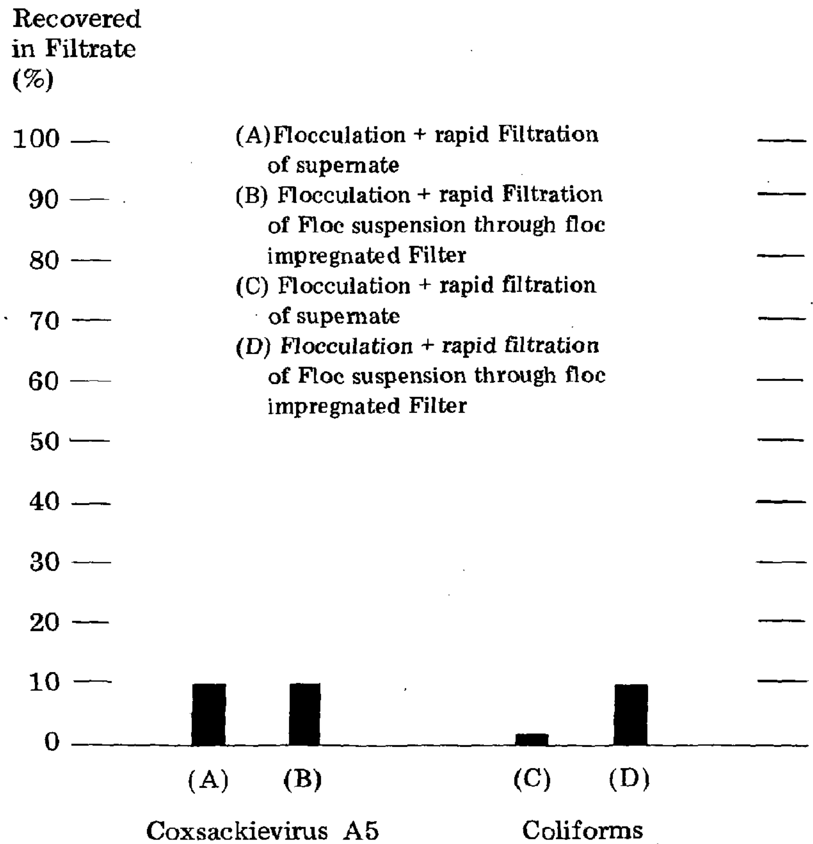
Figure 30
Effect of Flocculation:
Laboratory Study on the Removal of Virus, Bacteria, and Turbidity from Raw Ohio River Water

Temp. °C	Stage of Floccul.	Coagulant	Coxsackievirus A2* % removal	Coliforms	Initial Turbidity (ppm)**	Final	Final pH
	1	$Al_2(SO_4)_3$	96	99	40-135	1-5	6.7-7.4
5	2	$FeCl_3$	94	62	1-5	0.1-1	7.3-7.7
	1 and 2		99.6	99.95	...	0.1-1	...
	1	$Al_2(SO_4)_3$	95	94	140-255	1-5	6.7-7.4
15	2	$FeCl_3$	92	82	1-5	0.1	7.3-7.7
	1 and 2		99.6	99.9	...	0.1	...
	1	$Al_2(SO_4)_3$	99	99.8	16-240	1-5	6.7-7.3
25	2	$FeCl_3$	94	94	1-5	0.1	7.3-7.8
	1 and 2		99.9	99.99	...	0.1	...

*Virus seeded into raw water before flocculation.
** Good floc formed in all experiments.

Source: Berg, op.cit.

Figure 31
Effect of Rapid Filtration on Virus and Bacteria Removal



Recovery of coxsackievirus A5 and coliforms from spring water after coagulation and filtration through 30 inches of white sand (particle size 0.425 mm).

Source: Berg, op.cit.

Figure 32
Virucidal Efficiency of Free Chlorine in Water*

Source: Baumann, op.cit. p. 44

Virus	Temperature (C^{O})	Final pH	Free Chlorine (mg./1)	Virus Destruction (%/minutes)
Partially purified Theiler's	25-27	6.5-7.0	4.0-6.0	98.6/10
virus in tapwater	25-27	6.5-7.0	4.0-6.0	99/5
Feces-borne infectious hepatitis				
virus in distilled water	Room	6.7-6.8	3.25	(1)
Purified poliovirus 2 in distilled				
and lake water	19-25	7.4-7.9	1.0-1.5	(2)
Purified Coxsackie A2 in	3-6	6.9-7.1	.58-.62	99.6/10
demand-free water	3-6	6.8-7.1	1.9-2.2	99.6/4
	3-6	6.9-7.1	3.8-4.2	99.6/2½
	3-6	8.8-9.0	1.9-2.0	99.6/24
	3-6	8.8-9.0	3.7-4.3	99.6/9
	3-6	8.8-9.0	7.4-8.3	99.6/5
	27-29	6.9-7.1	.16-.18	99.6/4
	27-29	6.9-7.1	.44-.58	99.6/3
	27-29	8.8-9.0	.10-.18	99.6/10
	27-29	8.8-9.0	.27-.32	99.6/7
	27-29	8.8-9.0	.92-1.0	99.6/3
Purified poliovirus 1 (Mahoney)	0	6.0	.39	99.6/3½
in demand-free water	0	6.0	.80	99.6/1½
	0	7.0	.23	99.6/8
	0	7.0	.53	99.6/4½
	0	8.5	.53	99.6/16
	0	8.5	1.95	99.6/7½
	0	8.5	5.00	99.6/3
Purified poliovirus 1 (Mahoney)	25-28	7.0	.21-.30	99.9/3
in demand-free water	25-28	9.0	.21-.30	99.9/8
Purified poliovirus 3 (Saukett)	25-28	7.0	.11-.20	99.9/2
in demand-free water	25-28	9.0	.11-.20	99.9/16
Purified Coxsackie B5 in	25-28	7.0	.21-.30	99.9/1
demand-free water	25-28	9.0	.21-.30	99.9/8
	1-5	7.0	.21-.30	99.9/16
	1-5	8.0	.21-.30	99.9/30
Purified adenovirus 3 in	25	8.8-9.0	.20	99.8/40-50 sec.
demand-free water	25	6.9-7.1	.20	99.8/8-16 sec.
	4	8.8-9.0	.20	99.8/80-100 sec.
	4	6.9-7.1	.20	99.8/8-10 sec.

(1) 30 minutes contact time protected all of 12 volunteers.
(2) 10 minutes contact time protected all of 164 inoculated mice.
*Paul Kabler, "Viricidal Efficiency of Disinfectants in Water," *Public Health Reports*, XXXVI (July, 1961), p. 566.

Figure 33
Chlorine/HOCl Concentration for Virus Inactivation

Author ref. #	Type virus	Type water	Chlorine Level mg/1	Time min.	Temp °C	pH	HOCl mg/1
1	Type 1 poliovirus	Clean water	0.1	10	0	6.0	0.10
2	6 types enteric viruses	Clean water	0.3	30	25	7.0	0.23
3	Type 9 echovirus	Trickling F. effluent	1.4	30	20	7.8	0.45
4	Type 1 poliovirus	Sand fil. H.T.E.	0.8	30	25	7.4	0.46
4	Type 1 poliovirus	Treated dam water	0.4		25	7.9	0.11
5	T_2 bacterio-phage and Type 1 poliovirus	Extended aeration secondary effluent	0.3	30	20	7.4	0.17

1 Clarke, N., Berg, G., Kabler, P., & Chang, S., "Human Enteric Viruses in Water: Source Survival and Removability," *Adv. in Water Poll. Res.*, Vol. 2, 523-541. Pergamon Press, London, 1964.

2 Chang, S., "Waterborne Viral Infections and their Prevention." *Bull. Wld Hlth. Org.*, 38, 401-414, (1968).

3 Shuval, H., Cymhalista, S., Wachs, A., Zohar, Y., & Coldblum, N. "The Inactivation of Enteroviruses in Sewage by Chlorination," Third International Conference on Water.

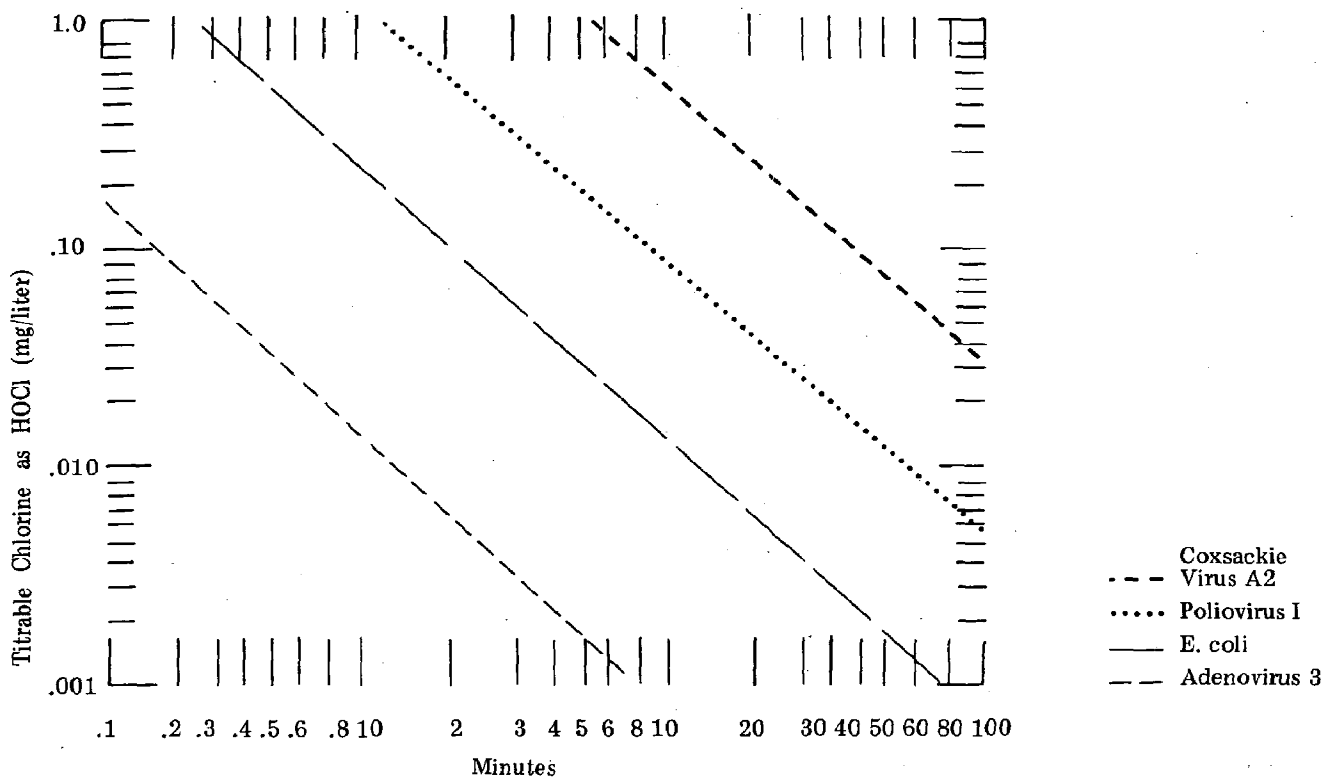
4 Marais, A., Nupen, E., Stander, G., & Hoffman, J., "A Comparison of the Inactivation of Escherichia coli I and Poliovirus in Polluted and Unpolluted Waters by Chlorination." *Proc. Conf. Water for Peace*, Washington, D.C., 670-687 (1967).

5 Lothrop, T., and Sproul, O. "High Level Inactivation of Viruses in Wastewater by Chlorination," J.W.P.C.F., 41, 7, 567-575 (1969).

Source: Nupen and Stander, op.cit., p. 6

It is important to note the influence of temperature on disinfection; higher temperatures yield much higher disinfection efficiencies, a point of interest to recreation planners. Body contact sports, which theoretically can lead to viral contamination of the water, occur only during the summer months, when the disinfecting efficiency of the treatment plant is highest. Figure 34, then, represents the minimum efficiency of HOCl as a viral disinfectant, as it is for the temperature range 0-6°C.

Figure 34
Virucidal Efficiency of Chlorine



Relationship between concentration and time for 99 percent destruction of *E. coli* and 3 viruses by hypochlorous acid (HOCl) at 0-6°C.

Source: Berg, op.cit.

Figure 35
Minimal Infective Doses of Attenuated Poliovirus for Human Hosts by Oral Route

Hosts	Virus	Dose (PFU's)	Carrier rate	% infected
Adults	Poliovirus type 1	200	4/4*	100
	(SM strain)	20	4/4	100
		2	2/3	67
		0.2	0/2	0
Premature infants	Poliovirus type 3	10	2/3	67
	(Fox strain)	2.5	3/9	33
		1	3/10	30

Source: Plotkin and Katz, op. cit.
*Number of persons developed into carrier for the virus/Number of persons who had taken the virus orally.

Again, these are laboratory studies, and they have been criticized for having little reference to practical conditions. But while one can agree that most treatment plants do not operate at the highest possible level of efficiency, current research has not yielded enough evidence to say that present techniques are ineffective in maintaining a safe water supply. Studies which show relatively low efficiencies for standard plants in removing viruses deal with only half the problem. The number of viruses which actually survive the distribution process (in which residual chlorine continues their attrition) and how many actually are required to produce infections must also be known.

Originally, it was felt that the number of viruses needed to produce an infection would range in the millions of particles,[10] but recent work indicates that it is much smaller. An important study by Plotkin and Katz,[11] found that one virus particle (PFU) can be an infective dose on oral route experiments. A summary of their findings is presented in Figure 35.

While an infected person does not necessarily show overt clinical symptoms — out of every 100 to 1000 people only one will[12] — he constitues a threat to the community as a carrier.

Standards for viruses may be instituted in coming years. The proposed EPA National Drinking Water Standards, which will replace the U.S. Public Health Standards, will not contain any viral standard because, among other things, a reliable viral-detection device is not available for use in local systems. However, tentative viral limits of 1 per liter or 5 per liter have been mentioned.[13]

Maintaining Dependable Treatment

Another issue is that of the dependability of the water treatment. An EPA survey[14] showed some distressing examples of substandard operations. Fifty-six percent of the systems evidenced physical deficiencies such as inadequate disinfection capacity and inadequate clarification capacity. Seventy-seven percent of the plant operators were inadequately trained in fundamental water microbiology; and 79% of the systems were not inspected by state or county authorities in the last full year prior to the study. In 50% of the cases, "plant officials did not remember when, if ever, a state or local health department had last surveyed the plant."

The effect of inadequate treatment is documented in a statistical analysis of waterborne disease outbreaks, covering the years 1946 to 1970.[15] Records were assembled which identified disease outbreaks, their sources and their causes.

Under outbreaks caused by surface source contamination were the following: contamination of the watershed, overflow of sewage or outfall near source, flooding, dead animals in the reservoir, and the use of contaminated surface water for supplementary source. The total number of outbreaks traceable to all these causes was 34, the number of cases involved were 2895. Under "Miscellaneous Reasons" for outbreaks are listed: use of water not intended for drinking, use of contaminated buckets, contaminated drinking fountains, deliberate contamination, contaminated ice, and 29 outbreaks for which insufficient data was assembled. Fifty-five outbreaks involving 3050 cases were identified. No outbreak was attributed to contamination through recreation on a surface supply.

One can see from the above that disease outbreaks involving water supply are caused by many factors, and that the total number of cases of illness reported is not that large. The total number of reported illnesses from all causes during the period 1949 to 1970 was 59,738. Of course, that does not count isolated instances of disease: an outbreak is defined as two or more cases of the disease. In addition, only those illnesses reported are included. Some evidence suggests as few as one case in ten is actually reported.

It is interesting to see how waterborne outbreaks are distributed among different sizes of systems. This analysis is presented in Figure 36. This clearly shows that the safest water supplies are those which serve large metropolitan areas. The incidence of disease drops sharply from 53.11/million served to 0.45/million served. This is logical, since the professionalism of the large city water system is of the highest quality.

Figure 36
Distribution of Waterborne Disease in Public Systems By Size of Community Served: 1949-1970

Size	Outbreaks	Cases	Illness/million served
<500	13	998	22.97
500-1000	10	2409	30.40
1000-5000	33	8732	23.73
5000-10000	8	8419	34.02
10000-25000	10	2725	7.00
25000-50000	6	18812	58.02
50000-100000	4	16725	53.11
>100000	16	779	0.45
Unknown	4	139	17.05

Source: G.F. Craun and L.J. McCabe, op. cit.

Conclusions

In this Appendix we have seen that presently available water treatment processes, if properly designed, operated and maintained, can produce water free of all pathogenic organisms. The processes described are the same as those used to treat water from rivers, which is generally of much lower quality than water from reservoirs. No amount of properly planned recreation can generate enough contamination of reservoir water to pose any technical difficulties in treatment. In some systems, recreation may require a higher standard of treatment than is currently provided, but this cannot be considered a drawback to expanded use.

Many significant contaminants of water which have recently received nationwide attention were not considered in the discussion above. These include man-made organic compounds and their derivatives contributed by industrial wastes, pesticides, fertilizers, urban runoff, etc. With limited exceptions (such as golf course use or fertilizers) none of these is associated with recreation activities. However, the Federal Safe Drinking Water Act is expected to lead to new standards for drinking water which will indirectly require the addition of rapid filtration to all systems which do not currently use it. This can only lead to enhanced prospects for recreation at reservoir sites.

Appendix II

Reference Material for Six States

This appendix contains supplementary reference material for the discussion of reservoir recreation in six states which was presented in Chapter 2. There are six sections to this appendix, one for each state. The first part of each section presents state laws and regulations related to recreation at water supply reservoirs. The other sections are not uniform in content, since the recreation issue has developed differently in different places. Where possible, a listing of reservoirs is given which shows the degree of recreation allowed at each, and the level of treatment available.

Connecticut

Laws and Regulations
1.1

Title 25:
Water Resources

A law directed against vandalism of public water supplies.

> Sec. 25-39. Pollution of drinking water. Any person who puts anything into a well, spring, fountain, cistern or other place from which water is procured for drinking or other purposes, with the intent to injur the quality of such water, shall be fined not more than five hundred dollars or imprisoned not more than six months. (1949 Rev, S. 4022.)

Bathing prohibited in Connecticut's reservoirs:

> Sec. 25-43. Bathing in and pollution of reservoirs. (a) Any person who bathes or swims in any reservoir from which the inhabitants of any town, city or borough are supplied with water, or in any lake, pond or stream tributary to any distribution reservoir, or in any part of any lake, pond or stream tributary to any storage reservoir, which part is distant less than two miles measured along the flow of water from any part of such storage reservoir, and any person who causes any filthy or impure substance into any such reservoir, whether distribution or storage, or any of its tributaries, or commits any nuisance in or about it or them, shall be fined not more than one hundred dollars or imprisoned not more than six months or both. For the purposes of this section, a storage reservoir is defined as an artificial impoundment of substantial amounts of water, used or designed for the storage of a public water supply and the release thereof to a distribution reservoir, defined for the purposes of this section as a reservoir from which water is directly released into pipes or pipelines leading to treatment or purification facilities or connected directly with distribution mains of a public water system. (b) No person, after notice has been posted that any reservoir, lake or pond, or any stream tributary thereto, is used for supplying the inhabitants of a town, city or borough with water, shall wash any animal or clothing or other article therein. No person shall throw any noxious or harmful substance into such reservoir, lake, pond or stream, nor shall any person, after receipt of written notice from the director of health having jurisdiction that the same is detrimental to such water supply, permit any such substance to be placed upon land owned, occupied or controlled by him, so that the same may be carried by rains or freshets into the water of such reservoir, lake, pond or stream, or allowed to be drained any sewage from such land into such water. Any person who violates any provision of this subsection shall be fined not more than one hundred dollars or imprisoned not more than thirty days or both. (1959, P.A. 632, S.1.)
>
> Cited, 100 C. 464; 111 C. 362. Is a valid exercise of police power even though it would deprive one property right as riparian owner. 123 C. 492.

The local government of a town has the power to prohibit recreational activities, though not to permit it.

> Sec. 25-45. Local ordinances concerning reservoirs. The legislative body of any city or borough may make, alter and repeal ordinances

to regulate or prevent fishing, trespassing or any nuisance in or on any property of such city or borough or of any subdivision thereof. Such ordinances may provide for the imposition of a fine not exceeding $50 dollars or imprisonment for not more than six months, or both, for a violation thereof. The common council of any city or the warden or burgesses of any borough may appoint special constables to protect reservoir property and to execute any such ordinance and any provision of the statutes relating to protection of water supply, and for that purpose constables shall have all the powers of constables of towns. (1949 Rev. S 403).

The following Act, passed in 1973, gives more power to the Department of Health to control recreation on reservoirs. It directly relates recreation and the quality of water treatment, but specifically states that recreational activities cannot be permitted which would require additional treatment to be installed at existing sites.

P.A. 73-522

Section 1. Sport fishing from designated locations on shoreline or from boats propelled by oars on public water supply storage reservoirs, as defined in subsection (a) of section 25-43 of the 1969 supplement to the general statutes, and additional recreational activities within designated areas of the watersheds of such reservoirs may be permitted by a water company, as defined in section 25-32a of the 1969 supplement to the general statutes, in accordance with rules made by such water company after consultation with the commissioner of health and the department of environmental protection. The commissioner of health may prohibit fishing and recreational activities in those cases where treatment facilities are deemed inadequate by the commissioner to properly safeguard the health of persons drinking the water.

Section 2. All public water supply reservoirs constructed on or after January 1, 1975, except for such reservoirs as may be under construction before January 1, 1975, shall have such water treatment or purification facilities as the state commissioner of health determines are necessary to assure the purity of the water supplies from sources in such reservoirs in which sport fishing is permitted or in watersheds of such reservoirs in which such recreational activities are permitted as provided in section 1 of this act, provided nothing in this act shall be deemed to permit any recreational use of an existing reservoir or of the watershed land of such reservoir which use would require the installation of new water treatment or purification facilities.

Section 3. Water companies are empowered, after consultation with the department of environmental protection, to issue permits and to charge fees for the issuance of such permits in order to reimburse such companies for the cost to them of such fishing and other recreational activities in public water supply storage reservoirs and on the water sheds of such public water supply storage reservoirs.

Section 4. No water company shall be liable in damages except with respect to willful or wanton conduct for injury or property damage to any person who enters upon its lands or waters under the provisions of this act.

Title 19:
Public Health Code:
19-13-B36: Public Bathing Establishments:

While Connecticut has no permit system for public bathing places, it does require that they meet general health standards. Paragraph (d) states: "All persons known or suspected of being afflicted with communicable diseases shall be excluded."

P.A. 74-303: Section 19-13-B99: Department of Health Approval for Sale of Water Company Land

This interesting new set of regulations regulates the sale of watershed land and seeks to expand control over watershed land use.

Section 1. The regulations of Connecticut state agencies are amended by adding Section 19-13-B99.

Section 2. No water company as defined in Section 25-32a of the General Statutes shall sell, lease or otherwise dispose of or change the use of any lands draining into a public water supply without prior approval from the commissioner of health. Approval shall be based upon conformance to the following standards:

(a) No watershed land shall be sold which lies within 250 feet of the shore of a storage or distribution reservoir when filled to capacity unless in the judgment of the commissioner of health there will be no adverse effect upon water quality. No such land shall be leased or its use changed without approval by the commissioner of health of both the terms of the lease and of the lessee, or of the proposed change in use.

(b) No watershed land shall be sold which lies within 100 feet of a watercourse tributary to a storage or distribution reservoir, unless in the judgment of the commissioner of health there will be no adverse effect upon water quality after taking into account the extent and nature of water treatment facilities provided. "Watercourse" means any river, stream, brook, waterway, reservoir, lake, pond, marsh, swamp, bog or other surface body of water. No such land shall be leased or its use changed without approval by the commissioner of health.

(c) Restrictions shall be placed in the deed or lease for watershed lands located over 250 feet from a reservoir or over 100 feet from a watercourse as designated in sections (a) and (b) which will effectively limit usage of the land as follows:

(1) No toxic or hazardous substances, including but not limited to gasoline, oil, sodium chloride, pesticides or heavy metals shall be discharged either on or into the ground or into any watercourse.

(2) All sewage and domestic waste shall be discharged to properly located and constructed subsurface disposal systems in accordance with the State Public Health Code. No such system shall be constructed to handle in excess of 200 gallons per day per acre of land occupied.

(3) No sodium chloride or other chemical or substance not approved by the commissioner of health shall be used for maintenance of roads, driveways or parking areas.

(4) The design of storm water drainage facilities shall be such as to minimize soil erosion and maximize absorption of pollutants by the soil. Drain pipes shall terminate at least 100 feet from the edge of an established water course and the discharge arrangement shall be so constructed as to dissipate the flow energy in a way that will minimize the possibility of soil erosion. Special provisions may be required in order to protect stream quality during the construction phase.

(5) No use shall be permitted which would violate the provisions of the State Public Health Code relating to watershed sanitation.

(6) No disposal of septic tank cleanings and no sanitary landfills or other refuse disposal areas shall be permitted.

(7) Use of nitrogen fertilizer shall not be such as to result in a nitrate nitrogen content in excess of 10 mg. per liter in the ground water passing from the fertilized area to adjacent properties.

Section 3. Applications filed under Sec. 2 shall include the following information:

(a) Name and address of the owner of the property.

(b) Location and acreage of the property, including a location map showing the location of all water courses on or within 250 feet of the property, all streets on or adjoining the property, all streets on or adjoining the property and all buildings on the property.

(c) Present and proposed uses of the property.

(d) The proposed deed restrictions.

(e) List any proposed exceptions to the State Public Health Code.

(f) The signature of a duly authorized official of the utility.

Massachusetts

Laws and Regulations
2.1

Massachusetts was among the first states to restrict contact with drinking water supply; its first laws restricting access were passed in 1879.

Under Section 160 of Chapter 111 of the General Laws, the Department of Public Health is given the authority to make examination of water supply to determine its fitness for domestic use.

160. Examination of Water Supply; Rules; Penalty for Violation.

> The department may cause examinations of waters to be made to ascertain their purity and fitness for domestic use, or the possibility of their impairing the interests of the public or of persons lawfully using them or of imperilling the public health. It may make rules and regulations and issue such orders as in its opinion may be necessary to prevent the pollution and to secure the sanitary protection of all such waters used as sources of water supply. It may delegate the granting and withholding of any permit required by such rules or regulations to state departments, boards and commissions and to selectment in towns, and to boards of health, water boards and water commissioners in cities and towns, to be exercised by such selectmen, departments, boards and commissions, subject to such recommendation and direction as shall be given from time to time by the department; and upon complaint of any person interested, the department shall investigate the granting or withholding of any such permit, and make such orders relative thereto as it may deem necessary for the protection of the public health and to restrain the use of such waters to the extent as in its opinion such use will not tend to adversely affect the public health. Whoever violates any such orders, rules or regulations shall be punished by a fine of not more than five hundred dollars, to the use of the commonwealth, or by imprisonment for not more than one year, or both. (1951).

Section 171 of Chapter 111 penalizes willful corruption of the water supply:

> 171. Willful Corrupting of Sources of Water Supply Penalized.
>
> Whoever wilfully deposits excrement or foul or decaying matter in water used for domestic water supply, or upon the shore thereof within five rods of the water, shall be punished by a fine of not more than fifty dollars or by imprisonment for not more than one month. A police officer or constable of a town where such water is wholly or partly situated, acting within the limits of his town, and any executive officer or agent of a water board, board of water commissioners, public institution or water company furnishing water or ice for domestic purposes, acting upon the premises of such board, institution or company and not more than five rods from the water, may without a warrant arrest any person found in the act of violating this section, and detain him until a complaint can be made against him therefor. But this section shall not interfere with the sewage of a town or public institution, or prevent the enrichment of land for agricultural purposes by the owner or occupant thereof. (1879).

Section 172 of Chapter 111 prohibits bathing:

172. Bathing in Sources of Water Supply Penalized.

> Whoever bathes in a pond, stream or reservoir the water of which is used for domestic water supply for a town shall be punished by a fine of not more than ten dollars (1884, 172; RL 75, S 129.)

Under Section 160 of Chapter 111 (quoted above), the Department of Health has issued rules and regulations which affect recreation on public water reservoirs:

> **Rules and Regulations for the Purpose of Preventing the Pollution and Securing the Sanitary Protection of Certain Waters Used as Sources of Public Water Supply.**
>
> The Department of Public Health, acting under the authority of Section 160 of Chapter 111 of the General Laws, and every other act thereto enabling, and in accordance with the provisions of Chapter 30A of the General Laws, hereby makes the following rules and regulations for the purpose of preventing the pollution and securing the sanitary protection of certain waters used as sources of public water supply. These rules and regulations shall remain in force until further order, except that from time to time they may be amended or added to by the Department of Public Health.
>
> 6. No person shall wade or bathe in, and no person shall, unless permitted by a written permit of the Board of Water Commissioners or like body having jurisdiction over such source of supply, fish in, enter or go in any boat, seaplane or other contrivance, enter upon the ice for any purpose including the cutting

or taking ice or cause any animal to go in or upon such source of water supply or tributary thereto.

7. All reports which may be made to any board of health, or to any health officer of any town, of cases of contagious or infectious disease occurring within the watershed of such source of water supply or tributary thereto, shall be open to the inspection at all reasonable times by the Board of Water Commissioners or like body having jurisdiction over such source of supply, its officers or agents.

2.2

Letter from Frederic E. Greenman, Assistant Attorney General, to John C. Collins, Department of Public Health

Mr. John C. Collins, Director
Division of Sanitary Engineering
Department of Public Health
State House
Boston, Massachusetts

Dear Mr. Collins:

We have had under consideration a request by your department for an opinion on the responsibilities of the Department of Public Health, of municipalities and of municipal officials in connection with the contamination of public water supply sources by the use thereof (with tacit or explicit permission of municipal officials) for recreational activities such as bathing, boating and fishing.

In substance, you ask,

1. If it is shown that persons have suffered illness because of consumption of contaminated water distributed by a municipal water supply agency, and that such contamination resulted from negligence of the public water supply officials or their employees, would the municipality be liable to civil damages or criminal penalities?
2. If such contamination were determined to have occurred by reason of recreational activities in such waters or on the watershed of such waters, and these activities had been permitted by the municipality contrary to the advice, recommendations, rules, regulations, or orders of the Department of Public Health, would the muncipal water supply officials be personally liable, civilly or criminally?
3. If such recreational activities had been authorized by special act of the Legislature, would the municipality or the municipal officials be liable civilly or criminally?

Because of the hypothetical nature of these questions we cannot render a formal opinion as to them.* However, because of the obvious importance of your questions, I am setting forth below a brief review of pertinent statutory provisions and judicial decisions. I hope that these will assist and guide you and the community officials concerned.

Although St. 1966, c. 685, § 3 transferred authority to administer water pollution abatement laws to the division of water pollution abatement control, the department of public health retains its responsibility over public health, sanitation and the prevention of contagious disease. (See Opinion of the Attorney General to Commissioner of Metropolitan District Commission dated February 16, 1967.) G. L. c. 111, § 160 authorizes the department of public health to "make rules and regulations and [to] issue such orders as in its opinion may be necessary to . . . secure the sanitary protection of all such waters used as sources of water supply." The department may apply to the Supreme Judicial Court or the Superior Court for enforcement of such rules and regulations or orders (§ 164). Criminal penalties (up to a $500 fine and one year in prison) may be imposed for the violation of any such orders, rules and regulations (§ 160).

On October 11, 1960, the Public Health Council approved "Rules and Regulations for the purpose of. . . securing the sanitary protection of certain waters used as sources of public water supply." Regulation #6 thereof states that:

"No person shall wade or bathe in, and no person shall, unless permitted by a written permit of the Board of Water Commissioners or like body having jurisdiction over such source of water supply, fish in, enter or go in any boat, seaplane,

*See statement of former Attorney General Paul A. Dever in 1935, appearing in the Report of the Attorney General for the Year Ending November 30, 1935, at page 31:

"The long-continued practice of this department and the precedents set by my predecessors in office indicate, what is undoubtedly the correct rule of law, that it is not within the province of the Attorney General to determine hypothetical questions which may arise, as distinguished from questions relative to actual states of fact set before the Attorney General, upon which states of fact public officials are presently required to act; nor is it the duty of the Attorney General to attempt to make general interpretations of statutes or of the duties of officials thereunder, except as such interpretations may be necessary to guide them in the performance of some immediate duty."

or other contrivance, enter upon the ice for any purpose including the cutting or taking ice or cause any animal to go in or upon such source of water supply or open water tributary thereto."

It seems clear from the above language that bathing or wading in a source of public water supply has been prohibited by a regulation adopted by the Department of Public Health. It is provided in said section 160 that violation of such a regulation shall result in a fine of not more than $500 or imprisonment of not more than one year, or both. These penalties would apply to the person or persons who violate the regulation by bathing or wading in a public water supply. Should local officials permit such bathing, etc. in a reservoir, the department could nonetheless proceed under § 164 *to enforce its regulation against* the offender by application to the Supreme Judicial Court or Superior Court.

Fishing, boating, and certain other activities in or upon a municipal water supply are permitted under Regulation #6, provided a written permit is obtained from local water officials. Section 160 allows such a delegation of authority by the department to local officials. However, this section goes on to limit the power of these local officials by making the exercise of the delegated authority to issue permits "subject to such recommendation and direction as shall be given from time to time by the department." Should a permit be granted on the local level, the department may "make such orders relative thereto as it may deem necessary for the protection of the public health and to restrain the use of such waters to the extent as in its opinion such use will not tend to adversely affect the public health." Thus, the Department of Public Health can exercise control over the granting of permits by local officials under Regulation #6, in that it can make a recommendation that a permit not be issued, and can order that the permit be revoked or modified if it is granted on the local level. Violation of such an order invokes the criminal penalties set out in § 160 ($500 fine or imprisonment for one year, or both). In addition, the department may apply for enforcement of its order under § 164.

It thus seems clear that the department could issue an order to a local public water supply official, for the purpose of securing the sanitary protection of water used as a source of water supply, and could apply for judicial enforcement of the order pursuant to G. L. c. 111, § 164. Section 160, which provides for criminal sanctions against "Whoever" violates such an order, is sufficiently broad to encompass punishment of a local water supply official; provided, of course, that he violates an order directed at him.

Similarly, any such official whose own conduct constitutes a violation of the aforementioned rules and regulations of the department may be held responsible under sections 160 and 164, in the same manner as anybody else who violates them.

It has been firmly established in this Commonwealth for many years that a municipality may be held civilly liable in contract or tort for injuries sustained through the consumption of impure water. In the well-known case of *Horton* v. *Town of North Attleborough*, 302 Mass. 137 (1939), the Supreme Judicial Court ruled that the plaintiff, who had become ill from drinking impure water supplied by the defendant, could recover damages from the town to compensate him for his injuries. At page 143 the Court states:

"The defendant [town of North Attleborough] in entering upon the business of supplying water, assumed the duty towards its customers of conducting the business 'with reasonable judgment, skill and care, according to the approved usages of. . .[the] trade', [*Kelley* v. *Laraway*, 223 Mass. 182, 184] and of using 'the ordinary care of the man of common prudence. . . .' Specifically, with regard to the purity of water supplied for drinking, the defendant owed the duty of furnishing at all times a supply of wholesome water, so far as that could be *done by the exercise of care, diligence* and skill which is ordinary and reasonable in view of the nature of the business."

By the same token, there is judicial authority for holding a public officer personally liable for civil damages when it can be shown that he has performed acts of misfeasance in carrying out his official duties. In *Moynihan* v. *Todd*, 188 Mass. 301, the Supreme Judicial Court said at page 305:

"For a personal act of misfeasance, we are of [the] opinion that a party should be held liable to one injured by it, as well in the performance of a public duty as when otherwise engaged."

In the event that such recreational activities *permitted by local officials* have been authorized by a special act of the Legislature, the imposition of the civil and criminal penalties discussed above would depend wholly upon the language of the act.

To summarize, it seems clear that if a city, town or water district were to allow the use of its water supply for purposes which could cause contamination, a person injured as a result of the contamination might recover damages from the municipality for negligence, and from officials thereof individually if an act of misfeasance is shown. As indicated above, the criminal penalties set out in G. L. c. 111, § 160 might also be applied to local water supply officials, to the same extent as to other persons, if they personally violate an order, rule or regulation of the Department of Public Health issued under said section 160.

I trust that the above information will be helpful to you and your department. Upon submission of a particular set of facts involving the performance of some immediate duty, we shall be pleased to render an opinion relative to those precise facts.

Very truly yours

Frederic E. Greenman
Assistant Attorney General
Chief, Division of Health,
Education and Welfare

New Jersey

Laws and Regualtions

3.1

Title 58:
Waters and Water Supply

New Jersey's attitude toward recreation on state-run reservoirs is liberal:

58:22-16 Use of Reservoirs for recreation:

The reservoirs constructed pursuant to this act shall available for public use for recreation, swimming, fishing and boating in such manner and to such extent as shall not impair the availability of water therein for potable or industrial use or endanger the water supply facility or any of the works or facilities of any purchaser of such water.

Two state reservoirs are established by state law, Round Valley and Spruce Run. The following sections use the same language in describing recreation opportunities on each:

58: 20-4 (Round Valley Reservation)

58: 21-5 (Spruce Run Reservation)

. . .shall be made available, as a *State reseroivr,* for recreation and other state uses consistent with its primary uses.

58: 21B-5 extends this policy to apply to all land acquired by the state in the future for use in a water supply system.

Title 7:
Environmental Protection
Chapter 10 — Bureau of Potable Water

Under 7: 10-5, rules for the licensing of operators and superintendants of water treatment facilities are ennumerated. Various degrees of education and field experience are required for the management of different sizes of systems and methods of treatment. Large systems with advanced treatment facilities have very strict standards for their personnel.

3.2 List of New Jersey Reservoirs

Reservoir	Location	Size Acres	Ownership	Recreation
Oradell Res.	Haworth	620	public	no
Riverdale	River Lake	1255	public	no
Woodcliff Lake	Woodcliff Lake	170	public	no
Oswego Lake	Washington	90	public	yes
unnamed	Washington	75		no
unnamed	Bass River	52		no
7 unnamed reservoirs	Bass River	113 Total		no
4 unnamed reservoirs	Washington	105 Total		no
Union Lake	Millville	920	private	no
Canoe Brook #1	Millburn	239	public	no
Canoe Brook #2	Millburn	138	public	no
Cedar Grove	Cedar Grove	85	public	yes
Orange Res.	West Orange	102	public	no
Res. #2	Jersey City	10	public	no
Res. #3	Jersey City	10	public	no
Round Valley	Clinton	2350	public	yes*
Spruce Valley	Union	1275	public	yes*
Dunhernal Lake	Madison	92	private	yes
Farrington Lake	East Brunswick	290	public	yes
Weston Mill Pond	East Brunswick	92	public	yes
Glendola Res.		124	private	no
Swimming River Res.	Middleton	102	private	yes
Boonton	Parsippany-Troy Hills	780	public	no
Clyde Potts	Mendham	50	private	no
Kikeout	Kinnelon	100	public	no
Canistear		350	public	yes*

Reservoir	Location	Size Acres	Ownership	Recreation
Charlotteburg		375	public	yes*
Echo Lake		300	public	yes*
Macopin Res.	Kinnelon	30	public	no
Splitrock Res.	Rockaway	640	public	no
Clinton Res.	West Milford	423	public	yes*
Great Notch Res.	West Paterson	28	private	no
Oak Ridge Res.	West Milford	197	public	no
Point View Res.	Wayne	512	private	no
Wanaque Res.	Wanaque	2310	public	no
Bound Brook Res.	Bridgewater	67	private	no
Culvers Lake	Frankford	692	private	no
Lake Rutherford	Wanton	100	public	no
Middlesex Res.	Clark	105	private	yes
Anxilliary Res.	Blairstown	45	private	no
Cedar Lake	Blairstown	29	private	no
Paulina Lake	Blairstown	10	private	yes
Upper Reservoir	Blairstown	164	private	no

*swimming permitted

Private	2,940 (18.2%)
Public	13,181 (81.8%)
Total	**16,121 (100%)**
Recreation Allowed	6,421 (39.8%)

This list was assembled from the March 1970 "Lakes and Ponds Inventory," published by the Department of Conservation and Economic Development, Division of Parks, Forestry and Recreation, Comprehensive Recreation Planning Section.

New York

4.1 Laws and Regulations

Public Health Law

1100: The department of health. (Under this section, the department of health may make rules and regulations protecting all state sources from contamination except for those used by the City of New York, which are controlled by the New York Administrator of Environmental Protection.)

1103:
(Under this section, a fine of up to $200 or one year in jail may be assessed for violation of rules and regulations set up under 1100.)

Under the statutory authority of the above, the Department of Health sets up standards as follows.

State Sanitary Codes:

Title 10, Chapter I: Section 11. (This section sets up classifications and standards for operators of water treatment plants.)

Subchapter C: Water supply sources. Section 170.1. Statement. The rules contained in this Part, together with the watershed rules and regulations hereinbefore set forth in Parts 100 through 158, have been promulgated to protect sources of water supply dedicated for present or future public beneficial use for domestic and municipal purposes.

170.2. Applicability and scope. This Part shall apply throughout the entire State of New York, except the City of New York, and shall apply to all sources of water supply in the State and classified, under the authority of article 12 of the Public Health Law in Parts 701 through 703 of Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York, as Classes AA, A, A-special (International boundary waters), AA-special (Lake Champlain drainage basin), AA-special (Upper Hudson River drainage basin) and GA.

170.3. Definitions. As used in this Part, the following words and phrases shall have the following meanings:
(a) Potable water means water suitable for drinking, culinary or food processing purposes.
(b) Protected from contamination includes, in addition to responsibility for the prevention of contamination, responsibility for the reservation, surveillance, storage, diversion collection, treatment, processing, distribution and use of water for domestic and municipal purposes.
(c) Source of water supply means any ground water, aquifer, surface water body or water course from which by any means water is regularly taken either periodically or continuously for drinking, culinary or food processing purposes or which has been classified for present or future public beneficial use as a source for domestic or municipal purposes.
(d) Contamination means any substance or characteristic which will make the water unsuitable or unsafe including a constituent or characteristic in an amount exceeding the allowable limits therefor hereinafter set forth.

170.4. Standards of raw water quality. Every source of water supply to which this Part is applicable shall meet the standards of quality hereinafter set forth and shall be protected from and free of contamination.

Item	Specifications	Constituent or Characteristic	Allowable Limits
1 Floating solids; settleable solids; oil; sludge deposits; taste or odor producing substances	None attributable to sewage, industrial wastes or other wastes.	Physical turbidity	5 units
2 Sewage or waste effluents	More which are not effectively disinfected.	Microbiological Coliform organism	50' per 100 ml. (concentration in mg/l)

Inorganic and organic chemical standards are also set.

While each city must meet the standards above (except New York City, which has similar standards of its own), each writes its own regulations for its particular water supply. They are different as regards recreation. The following is part of the regulations of the City of New York.

Chapter III. Public Water Supplies
Section 128. City of New York
(h) Washing, bathing, wading, swimming. No clothes or unclean objects of any kind shall be washed in any spring, marsh, water course or reservoir. Bathing, wading and swimming are prohibited in any water course or reservoir owned by the City of New York.

Not all cities make a specific reference to swimming or to other recreational uses of public water supplies, but when such reference is made to recreation it is to prohibit those other uses.

4.2 New York City Water System

New York City Water System

The New York City system draws an enormous amount of water from a variety of sources, mostly from the following reservoirs.

	Capacity (billion gals)
Scholarie	19.6
Ashokan	127.9
Cannonville	97.0
Pepacton	143.7
Neversink	35.5
Rondout	50.0
West Branch	10.1
Kenisco	30.6
Hill View	.9
New Croton	23.8
Muscoot	4.9
Boyds Corners	1.7
Bog Brook	4.4
East Branch	5.2
Middle Branch	4.0
Croton Falls Main	14.2
Croton Falls Diverting	.9
Titicus	7.2
Anawalk	6.7
Cross River	10.3

New York City allows no body contact recreation on its reservoirs, though most are accessible for low intensity recreation activities on the adjacent land. While the water is chlorinated and fluoridated, it is not filtered.

Recreation in New York 4.3

State Water Supply Reservoirs

The following cities, towns, water districts (W.D.S.) and water companies (W.C.S.) using reservoirs as part of their supply systems restrict water-based activities as shown below.

County City	No Swimming	No Boating No Fishing	No Boating (shore fishing allowed)
Albany County			
Albany	x	x	
Watervliet	x	x	
Altamont	x		
Ravena	x	x	
Latham W.D.	x	x	
McKownville W.D.			
Guilderland	x	x	
Bethlehem	x	x	
Cattaraugus County			
Olean	x		
Gowanda	x	x	
Cahutaugua County			
Brockton	x	x	
Fredonia	x	x	
Westfield	x		x
Chemung County			
Elmira	x	x	
Chenaugo County			
Norwich	x	x	
Bainbridge	x	x	
Sherburne	x		x
Clinton County			
Keenesville	x		x
Plattsburgh	x		
Peru	x		x
Columbia County			
Hudson	x		
Kinderhook	x		
Philmont	x	x	
Cortland County			
Cortland	x	x	
Delaware County			
Delta	x		x
Bovina	x	x	
Stamford	x		x

County City	No Swimming	No Boating Fishing	No Boating (shore fishing allowed)
Dutchess County			
Beacon	x	x	
Fishkill	x	x	
Hyde Park FD	x		x
Staatsburg	x		
Harlem Valley St. Hospital	x	x	
Erie County			
Akron	x	x	
Hamburg	x	x	
Orchard Park	x	x	
Gowards St. Hospital	x		x
Essex County			
Port Henry	x		x
Saranac Lake	x		
Schroon Lake WD	x	x	
Raybrook Hospital	x	x	
Fulton County			
Gloversville	x	x	
Broadelpin	x	x	
Northville	x	x	
Genessee County			
LeRoy	x		x
Oakfield	x	x	
Greene County			
Athens	x	x	
Catskill	x	x	
Herkimer County			
Little Falls	x		
Dolgeville	x	x	
Frankford	x	x	
Herkimer	x	x	
Jefferson County			

County City	No Swimming	No Boating No Fishing	No Boating (shore fishing allowed)
Watertown	x	x	
Lewis County			
Lowville	x	x	
Livingston County			
Avon/Genesco/ Lakeville Wd	x		
Livonia	x		x
Nunda	x	x	
Madison County			
Oneida	x	x	
De Ruyter	x	x	
Hamilton	x	x	
Monroe County			
Rochester	x		
Fairport	x	x	
Hilton	x		x
Scottsville	x		
Montgomery County			
Canajoharie	x	x	
St. Johnsville	x	x	
New York City			
Niagara County			
Middleport	x		x
Wilson	x		x
Oneida County			
Rome	x		
Utica	x	x	
Deansboro W.C.	x	x	
Sylvan Spring WC	x		x
Hamilton College	x	x	
Onandaga County			
Syracuse	x		x
E. Syracuse	x	x	
Jamesville WD	x	x	
Syracuse WC	x		
Ontario County			

County City	No Swimming	No Boating No Fishing	No Boating (shore fishing allowed)
Canandaigua	x	x	
Rushville	x	x	
Orange County			
Middletown	x		x
Newburgh	x	x	
Chester	x		
Cornwall	x		x
Florida	x		x
Highland Falls	x	x	
Maybrook	x	x	
Tuxedo Park	x		
Warwick	x		x
Newburgh Commonwealth WC	x	x	
U.S. Military Academy	x		
Orleans County			
Allsion	x		x
Lyndonville	x		x
Otsego County			
Oneonta	x	x	
Gilbertsville	x	x	
Milford	x	x	
Putnam County			
Cold Spring	x		
Renssallear County			
Troy	x		
Castleton	x	x	
Rockland County			
Haverstraw WC	x		
St. Lawrence County			
Canton	x	x	
Saratoga County			
Corinth	x	x	
Mechanicville	x	x	

County City	No Swimming	No Boating No Fishing	No Boating (shore fishing allowed)
Saratoga Springs	x	x	
Schuylerville	x		x
Schenectady County			
Delanson	x		x
Schuharie County			
Sharon Springs	x	x	
Middleburgh	x		x
Jefferson WD	x	x	
Seneca County			
Hornell	x	x	
Arleport	x	x	
Sullivan County			
Jeffersonville	x	x	
Monticello	x	x	
Livingston Manor WD	x	x	
Youngsville WD	x	x	
Calicoon WC	x		
Roscoe WC	x	x	
Lake Louise Marie WC	x	x	
Tioga County			
Waverly	x	x	
Tompkins County			
Ithica	x	x	
Cornell Univ.	x	x	
Ulster County			
Kingston	x	x	
New Paltz	x		
Sangertics	x	x	
Kerhonkson WC	x	x	
Warren County			
Glens Falls	x	x	
Lake George	x	x	
Bolton WD	x		
North Creek WD	x	x	
Warrensburg WD	x	x	
Washington County			
Whitehall	x	x	
Spring Brook WC	x	x	
Wayne County			
Lyons	x	x	
Newark	x		x
Savanna	x		
Westchester County			
Yonkers	x		x
Croton-on-Hudson	x		
Irvington	x	x	
Larchmont	x	x	
Mt. Kisco	x	x	
Peekskill	x	x	
Tarrytown	x	x	
New Rochelle	x	x	
New York Interurban WC	x	x	
Wyoming County			
Attica	x		
Perry	x	x	
Yates County			

Pennsylvania

Laws and Regulations
5.1

Title 25:
Rules and Regulations
Part I. Department of Environmental Resources Subpart C. Protection of Natural Resources Article II. Water Resources
Chapter 109. Waterworks

Disinfection and Filtration
109.51. General requirement.
(a) Only disinfected water shall be served to the public.
(b) All water supplies shall be equipped with facilities necessary to continuously apply to all water served a disinfectant approved by the Department. Such facilities shall provide a readily measurable residual as the water enters the distribution system.
(c) All new sources using surface water, and existing sources used for recreational purpose, shall be provided with filtration and disinfection facilities.

109.52. Supplies with disinfection.
(a) Where a water supply has a surface water source and the only treatment provided is disinfection, inspections shall be made of the watershed by the permittee at intervals as often as necessary in order to assure the protection of the supply from contamination.
(b) Records and reports of all inspections shall be kept by the permittee. Upon request he shall submit copies of these records to the Department.
(c) Whenever any such inspection reveals unsatisfactory conditions on the watershed, the permittee shall submit copies of such inspection to the Department within one week from the date of this inspection.

109.53. Supplies with disinfection and filtration.
Where disinfection and filtration are provided for surface water supplies, the permittee shall so control the sanitary conditions in and around a reservoir owned by the permittee as to protect the public health and meet the requirements of this Chapter.

Recreational Uses of Source
109.61. Disinfected supplies.
The recreational use of a water supply with a surface water source utilizing only disinfection treatment shall be prohibited and shall be effectively prevented by the permittee.

109.62. Disinfected and filtered supplies.
The recreational use of a surface water supply where both disinfection and filtration treatments are utilized may be permitted.

Chapter 193: Swimming and Bathing Places

193.28. Bathing beach contamination.
(a) The water in bathing beaches shall be considered contaminated for bathing purposes when one of the following conditions exist:
- (1) The fecal coliform density in five samples of said water collected on five different days exceeds a geometric mean of 200 per 100 ml.
- (2) The Department determines that any substance is being discharged or may be discharged into the water and is or may be hazardous to the health of persons using the bathing beach.

(b) When the fecal coliform density of any sample collected at a bathing beach exceeds 1,000 per 100 ml., daily samples from the beach area shall be collected by the permittee and analyzed for fecal coliforms for at least five consecutive days immediately following the finding. The results of the analysis shall be reported to the Department by the permittee within five days of the taking of the last of these five samples.

(c) Use of a bathing beach found to be contaminated shall be discontinued until written approval is obtained from the Department. Such approval shall be given by the Department when the Department finds that the waters of such bathing beach are no longer contaminated.

5.2 Major Pennsylvania Reservoirs

City Served	Reservoir Name	Recreation
Altoona	Containing Point	hunting
	Impounding Dam	
	Lake Altoona	
	Milrun Reservoir	
	Homer's Gap	
Erie	Sigsbee Reservoir	none
	Cherry Street Reservoir	
	Johnson's Reservoir	
Harrisburg	unnamed on Dehart Dam	none
	2 unnamed in Reservoir Park	
Lancaster	Oyster Point Reservoir	none
Philadelphia	Oak Land Reservoir	none
	East Park Reservoir	limited
Pittsburgh	Highland Reservoir #1	limited
	Highland Reservoir #2	
	Herron Hill Reservoir	
	Bedford Reservoir	
	NcNaugher Reservoir	none
	Brashear Reservoir	
York	Lake William	shore fishing
	Lake Redman	

Rhode Island

6.1 Laws and Regulations

Title 46:
Bathing in public water supply prohibited:

"46-14-1. Pollution or misuse of drinking water sources prohibited. — No person shall throw or discharge, or suffer to be thrown or discharged, into any well, spring, brook, lake, pond, reservoir, stream or any watershed or drainage area used as a source of water supply for drinking purposes by any city, town, district, institution or company, or into any known tributary or feeder of any such well, spring, brook, lake, pond, reservoir, stream or any watershed or drainage area, any sewage, drainage, refuse or other noxious matter or thing tending to pollute or corrupt, or impairing or tending to corrupt the purity of the waters of any such well, spring, brook, lake, pond, reservoir or stream or watershed or drainage area or any known tributary or feeder thereof, or render the same injurious to health. Nor shall any person bathe, swim, or wash any animal, clothing or any other article in any of the above-mentioned waters; provided, however, that the prohibition against bathing shall not apply to any camp or bathing resort located on a known tributary of any of the above-mentioned waters if such camp or bathing resort was licensed by the department of health prior to June 20, 1968.

Any person violating any of the provisions of this section shall be punished for each offense by a fine of not exceeding four hundred dollars ($400.00) or by imprisonment for a term not to exceed one (1) year, or both."

6.2 Major Rhode Island Reservoirs

Reservoir	Owner	Treatment
Anawan Shad Factory Swansea	Bristol City Water Co.	rapid filters chlorination
Sneech Pond	Cumberland Water Dept.	chlorination
Carr's Pond Spring Lake Washington Mishmock	Kent County	chlorination
North Pond South Pond Nelson's Pond Gardiner's Pond Sisson's Pond St. Mary's Pond Lawton Valley Res. Nongmit Pond H.E. Watson Res.	City of Newport, Department of Water	
Diamond Hill Res. Arnold Mills	City of Pawtucket Water System	filtration chlorination
Scituate Reservoir Complex Scituate Reservoir Regulating Reservoir Westconnaug Barden Muswansicut Ponagansett	Providence	chlorination
Stafford Pond	Stone Bridge Fire District Water Department, Tiverton	
Reservoir #1 Reservoir #3 Harris Pond, Mill River	City of Woonsocket, Water Department	
Wallum Lake	Dr. V.E. Zambarano, Memorial Hospital, Burrillville	

Notes

1 Reservoir Recreation in Perspective

1 Jasper Own Draffin, *The Story of Man's Quest for Water*, Garrard Press, Illinois, p. 5.

2. Philip Hone, diary entry, December 17, 1835, in Blake, *Water For Cities*, Syracuse University Press, 1956, p. 143.

3. Spoken in legislative hearings in Boston in 1845 in course of debate over whether citizens were endangered by existing sources of water, Blake, *op. cit.*, p. 252.

4 Blake, *op. cit.*, p. 258.

5 In the Pacific Northwest, a similar negative attitude toward reservoir recreation is common. The area has water resources just as abundant as the Northeast, with less population. Similar high standards of raw water are possible there, and in places like Seattle, for instance, the voters have endorsed the luxury of owning completely isolated and regulated watersheds.

6 E. Jerry Allen, "The Function of the Purveyor," *Journal of the American Water Works Association*, May 1973.

7 Ralph Stone & Helen Friedland, "Socioeconomics of Multiple Uses," *Journal of the American Water Works Association*, June 1972.

8 Richard Woodhull, "Drinking Water Policy and Practice in Connecticut," p. 6.

2 Reservoir Recreation in Six Northeastern States

Connecticut

1 Published by the State of Connecticut, Department of Finance and Control, Office of State Planning, in coordination with the State Department of Health, the Department of Environmental Protection, the Department of Transportation, and the Regional Planning Agencies. Copies are available from the Connecticut Office of State Planning, Department of Finance and Control, 340 Capitol Avenue, Hartford, Connecticut 06115.

2 The concern of the Department of Health with the urbanization of watersheds is illustrated by several of their publications. Among others, the following Department of Health pamphlets are recommended:

"Drinking Water Policy and Practice in Connecticut."
by Richard Woodhull, M.S., P.E.
Chief, Water Supplies Section

"Sodium in our Drinking Water"
by Richard Woodhull, M.S., P.E.
Chief, Water Supplies Section

"The Role of the State Health Department in Water Supply Planning"
by Donald C. Smith, B.S.
Senior Sanitary Engineer
Water Supplies Section

Pennsylvania

1 Edward Robert Parmer, "Recreational Use of Community Water Supply Reservoirs in Pennsylvania," College of Health, Physical Education and Recreation, Pennsylvania State University, August 1973.

Rhode Island

1 "On the Multiple Use of Reservoir Areas," Providence *Journal* (editorial), Providence, Rhode Island, April 14, 1960.

Notes (Continued)

3 Planning Increased Recreation

1 In order to maintain the safe minimum distance between hunters and non-hunters, the holdings must be considerably greater if they take the form of a ring around the reservoir. The situation must be analyzed for safety at every site.

2 This method is elaborated in George Fogg, *Park Planning* Guidelines, *op. cit.*

3 United States Water Resources Council, *Procedures for Evaluation of Water and Related Land Resources,* Serial No. 92-30 (USGPO: Washington, September 1971).

4 Duane D. Baumann, *The Recreational Use of Domestic Water Supply Reservoirs: Perception and Choice*, Report 121, University of Chicago, Department of Geography, 1969.

Appendix I
The Effectiveness of Modern Water Treatment in Removing Pathogenic Organisms

1 Robert Grady, "The Effect of Recreational Use on the Quality of Sebago Lake Water," *Journal of the New England Water Works Association,* Vol. 86, No. 2, 1972.

2 *E. coli.* (Escherichia coli) is one of the coliform organisms. Most routine testing seeks only the general coliform group, but more careful research counts one species — *E. coli.* While there is a movement toward specifying the identification of *E. coli* for examining recreational water quality, the general coliform group is still used as the standard indicator for drinking water purity.

3 In 1959, Keene, New Hampshire, experienced such an incident. Shortly after one of the town's four sand filters had been cleaned, torrential rains evidently carried typhoid bacteria down from the watershed where it had been deposited by an infected lumberman. Since the filtration plant was operating at lower efficiency because of the cleaning of one filter, the bacteria passed through the plant and caused an outbreak of typhoid. A standard disinfection procedure would have prevented this. The town installed a chlorinator immediately.

4 A recent study by the Environmental Protection Agency has shown the presence of carcinogenic chemicals in the water supply of the City of New Orleans. They are apparently created by the interaction of chlorine with impurities in the Mississippi River water, which the City uses as a source. Chlorine enters the water in large doses in disinfected sewage effluent dumped into the river. It is contributed in much smaller amounts by drinking water treatment plants. This study has caused the worry that the practice of chlorination in general is dangerous. As far as is presently known, chlorination of reservoir water which is free of industrial chemicals, fertilizers, and pesticides has no dangerous effects. If further studies reveal a significant danger, it is possible to switch to other methods of disinfection, such as ozonation.

5 Berg, *op. cit.*, p. 176.

6 Infectious hepatitis must be distinguished from serum hepatitis, which is usually caused by unsanitary hypodermic syringes. Serum hepatitis is the less common disease; 9402 cases were reported in 1972 as opposed to 54,074 cases of infectious hepatitis.

An outbreak of hepatitis caused by an infected water supply occurred in Worcester, Massachusetts, in 1969. Members of the Holy Cross College football team drank water from a community supply which had inadvertently been cross-connected with a contaminated ditch for a short time. The contamination occurred in the distribution system, and was not caused by a failure of water treatment at a central plant. Ninety-four cases developed.

7 F.W. Gilcreas and S.M. Kelly, "Relation to Coliform-Organism Test to Enteric-Virus Pollution," *Journal of the American Water Works Association,* Vol. 47, (1955): 683-694.

8 Berg, *op. cit.*, p. 173.

9 Ethel M. Nupen and H.J. Stander, "The Virus Problem in the Windhoek Waste Water Reclamation Project," National Institute for Water Research, Pretoria, Republic of South Africa, June 1972, p. 2.

10 Taylor, *op. cit.*, p. 308.

11 S.A. Plotkin and M. Katz, "Minimal Infective Doses of Attenuated Poliovirus for Man," *Journal,* American Public Health Association, Vol. 57 (1967): 1837-1840.

12 From testimony of James McDermott, Chief of EPA Water Supply Division, to the U.S. Senate Hearings on water supply legislation, 1972, in Taylor, *op. cit.*, p. 308.

13 Taylor, *op. cit.*, p. 310.

14 J.H. McDermott, *Community Water*

Notes (Continued)

Supply Study: Significance of National Findings, Water Hygiene Division (now Water Supply Division), U.S. Environmental Protection Agency, 1971.

15 Gunther F. Craun and Leland J. McCabe, "Review of the Causes of Waterborne Disease Outbreaks," *Journal of the American Water Works Association*, January 1973.

Glossary of Terms

Activated Carbon: A form of carbon in which granules are produced with an enormous surface area in relation to particle size. Organic impurities in the water adhere to the carbon surface and thus are removed from the water. Very effective in removing odors and tastes from water, as well.

Algae, Plankton: Microscopic plant and animal growths which can occur in lakes and reservoirs. Plankton is a generic term for algae (microscopic plants) fungi, protozoa, and rotifera which can impart oily, fishy, aromatic, grassy, or other odors or tastes to the water.

Artesian Flow: A somewhat unusual condition in which groundwater is held below rocks under pressure, and can be released to flow without pumping.

BOD: Abbreviation for Biochemical Oxygen Demand. The amount of dissolved oxygen used by microorganisms in the biochemical oxidation of organic compounds in the water.

Carrier: Term for a person who has been infected with a contagious disease, but who, although he has no symptoms, continues to secrete the microbial or viral agents of the disease. A carrier may thus unwittingly transmit the illness to others.

Chlorination: The practice of treating water with chlorine to destroy potentially harmful bacteria and viruses. Sometimes used to control taste and odor problems caused by algae.

Coliform Count: The number of coliform colonies found in a standard sample of 100 ml of water. The count is a standard indicator of bacterial contamination, and should be virtually zero at all times in drinking water.

Contact Time: The time during which residual chlorine is present in water before it is consumed, or is otherwise neutralized. Water may be held at the treatment plant in holding basins to assure adequate time to kill all pathogens; the contact time can include the time water travels in pipes to the first user.

Copper Sulfate: An algicidal chemical used to kill algae and plankton when they appear in objectionable numbers on reservoir water. A porous bag of the chemical is towed across the reservoir by a boat.

Cross Connection: *Term describing an accident in which* sewerage lines or other sources of contaminated water become connected with the water distributed lines.

Distribution System: The system of pipes, tanks, pumps, and distribution reservoirs which brings water from a treatment plant to the consumers.

Dose: In chlorination, the amount of chlorine administered to the water. It should be enough to take up the chlorine demand of the water and provide an acceptable residual above that to accomplish complete disinfection.

Enteric Illness: A generalized illness of the intestinal tract, defined by symptoms which may include nausea, vomiting, diarrhea, etc. Usually used as a generic term for low grade illnesses for which specific cause can be shown. Can be water-borne by viruses or bacteria.

Filtration: The practice of filtering water through beds of sand or coal to remove color and turbidity, control tastes and odors, and remove substantial amounts of bacteria. *Rapid Sand Filtration:* Preceeded by coagulation, flocculation and sedimentation, rapid sand filtration is effective in removing color, turbidity, and bacteria from the water. *Slow Sand Filtration:* Water is applied to sand without previous treatment. The process is highly effective in removing turbidity and bacteria, but not effective in removing color.

Finished Water: Water which has been treated and is ready for distribution and consumption.

Flocculation: Used in conjunction with rapid sand filtration. Addition of a coagulant such as alum, lime, caustic soda, or soda ash produces a "floc" in the water which carries down with it color and turbidity, and also increases the efficiency of bacterial removal.

Ground Water: Water which is flowing underground, and which can be extracted by wells. Depth at which ground water is found influences its quality, with sources close to the surface more susceptible to contamination.

Hardness: Hardness is the sum of dissolved calcium and magnesium minerals in water. It is typically encountered in waters that have been in contact with limestone formations or in waters from arid regions. Excessive hardness makes water difficult to wash with.

Heavy Metals: A reference to metals such as barium, cadmium, lead, mercury, and silver which can be introduced into the environment by corrosion or through industrial processes and which are toxic to living organisms.

Impoundment: A body of water created by damming a stream or river and producing an artificial lake; a reservoir.

Infectious Dose: The minimum number of infectious particles which can cause a person to contract a disease. It was once thought that many thousands of viruses would be required to infect a person with a disease, but that has been revised down to where it is now thought that a single virus particle can cause infection.

Infectious Hepatitis: A viral disease which infects the liver, and can be transmitted by water. It is to be distinguished from serum hepatitis which is contracted by use of unsterile hypodermic syringes and similar devices.

Intake: The place at which water is withdrawn from a terminal reservoir to a treatment plant.

MGD: Abbreviation for "Million Gallons per Day," the typical measurement of treatment plant capacity.

Morbidity Rate: The number of cases of disease of a certain type in a given population, usually one hundred thousand or one million.

Mortality Rate: The number of deaths cause by a certain disease in a population of a given number, usually one hundred thousand or one million.

Ozonation: A disinfection technique frequently used in Europe and Canada instead of chlorination. While more powerful than chlorination, it leaves no "residual" which is useful as an indicator of continued disinfection in the distribution system.

Pathogen: An organism or virus which causes disease.

Pesticides: Poisons used for the control of insect pests in agriculture, and forestry, which can be deposited on watersheds and transported into the reservoirs. They may have various toxic effects on humans.

pH: The acidity or alkalinity of water measured on a scale from 1 to 14. A pH below 8 can lead to corrosion in pipes and introduction of lead or other metals into the water. pH is usually controlled to between 7.0 and 9; at this level it is slightly alkaline.

Raw Water: The water drawn into a treatment plant from the terminal reservoir.

Reservoir: *Storage or Collection Reservoir:* The larger reservoirs in the system which receive waters from tributary streams and hold the reserve water which the city requires.
Terminal Reservoirs: Smaller reservoirs directly adjacent to

treatment plants receiving their water from Collection Reservoirs, and holding from a few days' to six months' supply. *Distribution Reservoir:* Reservoirs (or tanks) within the distribution system used to maintain constant pressure and compensating for variations in demand by the community.

Runoff: The portion of water falling on a watershed which does not penetrate the earth but runs off across the surface; runoff is the mechanism by which the reservoirs collect water. Excessive runoff may occur when the ground is not covered with adequate vegetation or when the ground is very dry or very wet; the runoff water then carries silt and other contaminants which degrade reservoir water quality.

Sedimentation: The process of holding water in basins in order for solid particles and floc to settle out.

Softness: A term denoting the absence of dissolved calcium and magnesium in domestic water, making it easy to wash with, and good for cooking.

Surface Supply: A supply of domestic water taken from natural lakes, artificial reservoirs, streams or rivers.

Typhoid: A bacterial disease, transmitted by water, which was often fatal, and was greatly feared up until the mid-twenties, when modern water treatment, pasteurization of milk, and other public health measures succeeded in eliminating it almost entirely.

Virus: The smallest pathenogenic particle known. A virus is on the borderline between living and dead material. Some types are quite resistant to disinfection compared to enteric bacteria, and thus can survive chlorination more readily than can bacteria. Viruses are extremely small, being visible only under electron microscopes, and no standard and reliable method to discover their presence in water supplies has been discovered. They can cause many diseases, from the most trivial to the most fatal.

Water-borne Disease: *A disease which may be transmitted by water.*

Watershed: The area of land which drains into a reservoir; more generally, the area of land which drains into a specific stream or river network.

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